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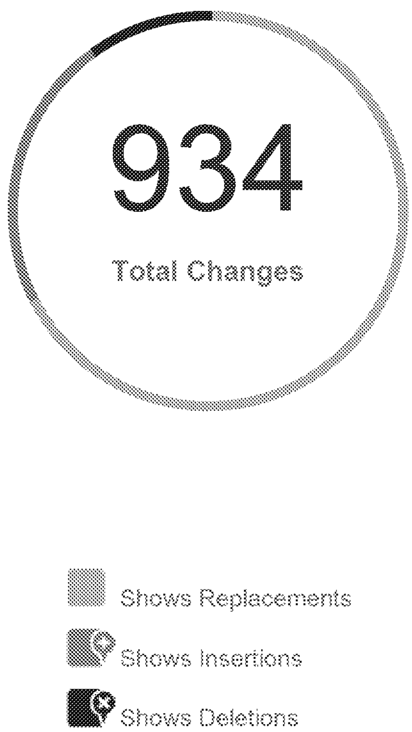
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FEASIBILITY STUDY REPORT

ROLLING KNOLLS LANDFILL SUPERFUND SITE

CHATHAM, NEW JERSEY

Prepared for

Rolling Knolls Landfill Settling Parties

Prepared by

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ACRONYMS

AMSL	Above Mean Sea Level
ALM	Adult Lead Methodology
APC	Area of Potential Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ARS	Alternative Remediation Standard
BERA	Baseline Ecological Risk Assessment
BGS	Below Ground Surface
BHHRA	Baseline Human Health Risk Assessment
BTV	Background Threshold Value
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Cleanup, and Liability Act
COC	Constituent of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CTBH	Chatham Township Board of Health
CTE	Central Tendency Exposure
DSRA	Development and Screening of Remedial Alternatives
ELCR	Excess Lifetime Cancer Risk
ERAGS	Ecological Risk Assessment Guidance for Superfund
FHA	Flood Hazard Area
FS	Feasibility Study
GSNWR	Great Swamp National Wildlife Refuge
GVFD	Green Village Fire Department
GWQS	Ground Water Quality Standard
HASP	Health and Safety Plan
HI	Hazard Index/Indices

HQ	Hazard Quotient
HQ_{LOAEL}	Hazard Quotient for the lowest observable adverse effect limit
HQ_{sed}	Hazard Quotient for sediment
IGWQC	Interim Ground Water Quality Criterion
IGWSSL	Impact to Ground Water Soil Screening Level
MESA	Memorandum on Exposure Scenarios and Assumptions
MNA	Monitored Natural Attenuation
NCP	National Contingency Plan
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NRDCSRS	Non-Residential Direct Contact Soil Remediation Standard
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbon
PAR	Pathways Analysis Report
PbB	Blood Lead Concentration
PCB	Polychlorinated Biphenyls
PCDD/F-TEQ	Polychlorinated Dibenzo-p-Dioxin/Furan Toxic Equivalent Quantity
POI	Point of Interest
PRG	Preliminary Remediation Goal
RA	Remedial Action
RAO	Remedial Action Objective
RDCSRS	Residential Direct Contact Soil Remediation Standard
RI	Remedial Investigation
RIR	Remedial Investigation Report
RME	Reasonable Maximum Exposure

ROD	Record of Decision
SCSR	Site Characterization Summary Report
SEM-AVS	Simultaneously Extracted Metals/Acid Volatile Sulfide
SI	Site Investigation
SLERA	Screening Level Ecological Risk Assessment
SRS	Soil Remediation Standards
SVOC	Semi-Volatile Organic Compounds
TAL	Target Analyte List
TBC	To Be Considered
TCL	Target Compound List
TMCT	Technical Memorandum on Candidate Technologies
TOC	Total Organic Carbon
TRV	Toxicity Reference Values
µg/dL	Micrograms per Deciliter
USEPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
UST	Underground Storage Tank
VI	Vapor Intrusion
VOC	Volatile Organic Compound
WRA	Well Restriction Area

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EXECUTIVE SUMMARY

This Feasibility Study Report (FS Report) has been prepared for the Rolling Knolls Landfill Superfund Site (the Site) in Chatham, New Jersey. The purpose of this FS Report is to conduct a detailed evaluation of each remedial alternative identified for soil and groundwater to reduce unacceptable risks to human health and the environment. The results of this FS will be used by United States Environmental Protection Agency (USEPA) to develop a Proposed Plan for remedial action and a Record of Decision for the Site.

The landfill covers approximately 170 acres, including one area of approximately 140 acres with a layer of waste material (18 feet or less in thickness) overlying native soil and a second area of approximately 30 acres with isolated areas of debris on the surface, referred to as the Surface Debris Area. The landfill was used for disposal of municipal waste from Chatham Township and nearby municipalities from the 1930s to approximately 1968. Landfilled materials were generally consistent with typical municipal solid waste expected within a landfill operating during this period. Evidence of potential industrial waste, identified based on visual observations and analytical results, were observed at three isolated areas, comprising only a small proportion of the total volume of waste disposed of at the landfill. The landfill is covered in some areas by a thin layer of soil and/or vegetation, and in others the waste is visible at the surface. Historical operations of the landfill included the application of pesticides for mosquito and rodent control on the landfill and the surrounding area.

Approximately 130 acres of the landfill are owned by the Trust created by the Last Will and Testament of Angelo J. Miele (Miele Trust). Approximately 35 acres of the landfill are in the Great Swamp National Wildlife Refuge (GSNWR) and are owned by the United States Fish and Wildlife Service (USFWS). Five acres of the landfill are owned by the Green Village Fire Department (GVFD). The Surface Debris Area is adjacent to the landfill and has debris scattered on the ground surface but no buried waste, and is owned by the Miele Trust. The Site, for purposes of the RI/FS, also includes a Baseball Field and Shooting Range, which are located off the landfill on the GVFD property.[1]

The Site is located at the southern end of Britten Road in the Green Village portion of Chatham Township. Green Village is a scenic, rural village oriented along Green Village

[1] Under the Settlement Agreement and Administrative Order on Consent for performance of the RI/FS, the Site includes these areas; however, the RI has confirmed that there are no landfilled materials and no impacts from the landfill to the Baseball Field or Shooting Range. Accordingly, after the FS these areas should not be considered part of the Site.

Road. Green Village Road is a 2-lane (one in each direction) county road with residential and limited commercial development on each side. Britten Road intersects Green Village Road and is primarily residential. Britten Road is approximately 1.5 lanes wide and is the only road that provides access to the Site. The Site is approximately 5.5 miles from the nearest major road, State Route 24, and is accessible only by driving through residential and commercial areas of Chatham.

Wetlands and flood hazard areas (FHAs) occupy the adjacent areas to the east, south, and west of the Site and portions of the landfill itself. Areas on and adjacent to the landfill provide habitat for native mammals, fish, amphibians, and reptiles, including the endangered bog turtle, Indiana bat, and blue-spotted salamander.

Site conditions and constituent concentrations in soil, sediment, surface water, and groundwater have been characterized through several phases of investigation since 2007. Analytical results indicate that metals, semi-volatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs) are present in surface soil at concentrations greater than New Jersey Soil Remediation Standards (SRS). Volatile organic compounds (VOCs) are present in groundwater in limited areas of the Site and certain metals are also present at concentrations above the New Jersey Ground Water Quality Standards (GWQS, including the Interim Ground Water Quality Criteria [IGWQC] which the New Jersey Department of Environmental Protection [NJDEP] enforces as groundwater standards), in groundwater below and near the landfill.

Ecological and human health risk assessments have been completed to assess the risks associated with the Site. The human health risk assessment indicated that, for current exposures and reasonably anticipated future exposures, all estimated cancer risks and the majority of non-cancer health hazard to human receptors are within or less than USEPA target levels. For landscapers that currently store and maintain equipment in one area of the landfill, the estimated non-cancer hazard is slightly greater than the USEPA target level, but Hazard Indices (HIs) for individual target organs are all less than or equal to the USEPA target level of 1. The estimated non-cancer health hazard to adolescent and adult trespassers that at times may enter the landfill, or that may reasonably be anticipated to enter the landfill in the future, is greater than the USEPA target level.

The results of the ecological risk assessment indicate that exposures to constituents in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robins through exposure to certain constituents in soil.

Based upon an agreement with the Miele Trust, the portion of the Site located on the Miele Trust property will be preserved as open space in perpetuity. Similarly, the area of the Site in the Great Swamp is also preserved with no future development. The small portion of landfill on the GVFD property is not eligible for development. Accordingly, while the BHHRA evaluated risks to potential receptors if the Site were to be developed residentially, such use will not occur. Further, there will be no commercial, industrial, recreational, or any other use. The only potential human exposures are to trespassers.

Statistical analysis using the concentrations of the primary risk driver in soil (dioxin-like PCBs) identified an approximately 25-acre area of the Site which if remediated would lower the risk levels at the Site to below USEPA's acceptable risk range (Selected Area). The risk levels in the soil outside of Selected Area are within USEPA's acceptable range. In addition to the Selected Area, additional areas were considered for remediation based on several different criteria. First, given the that the future Site use only results in potential exposure to trespassers, Alternative Remediation Standards (ARSs) were developed in accordance with NJDEP regulations (N.J.A.C. 7:26D; NJDEP, 2017) to account for the exposure scenarios that are appropriate to that use. Thus, ARSs were developed for constituents that exceeded New Jersey's Non-Residential Direct Contact Soil Remediation Standards (NRDCSRS). Based on the ARSs, seven Areas of Particular Concern (APCs), consisting of sample locations containing contaminant concentrations three times the ARS, were identified for additional remediation. Second, several mostly non-vegetated areas were identified (which are areas that can be accessible to trespassers with insufficient vegetation to cover soil) that may contain a contaminant concentration above the ARS remediation goal, which potentially require additional evaluation and remediation. The remedial alternatives presented in this FS include evaluation of potential remedial actions for these areas.

Based on the results of prior screening of remedial options, the following five Remedial Alternatives for soil were evaluated in this FS:

1) No Action;
2) Site Controls (i.e., Institutional Controls and Access Restrictions);
3) Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals;
4) Site Controls, Excavation and Off-Site Disposal of Select Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals; and,
5) Site Controls and Capping of All Landfill Material.

The following table summarizes the characteristics of each Soil Remedial Alternative when compared to USEPA's evaluation criteria.

Evaluation Criteria	Soil Alternatives				
	1	2	3	4	5
Overall Protection of Human Health and the Environment	Poor	Good	Excellent	Excellent	Excellent
Compliance with ARARs	Poor	Good	Excellent	Excellent	Excellent
Long-Term Effectiveness and Permanence	Poor	Moderate	Excellent	Excellent	Excellent
Reduction of Toxicity, Mobility, and Volume Through Treatment	None	None	None	None	None
Short-Term Effectiveness	NA	Excellent	Good	Moderate	Poor
Implementability	NA	Excellent	Excellent	Excellent	Excellent
Costs	$0	$671,000	$16,329,000 to $21,888,000	$34,539,000 to $35,376,000	$59,216,000

NA - Not Applicable
For Soil Alternatives 3 and 4, the range of costs reflects differing remedial approaches included within the alternative.

The No Action alternative provides the least overall protection but entails no impact to the surrounding community and has no cost. Soil Alternative 2, Site Controls, provides good overall protection and compliance with Applicable and Relevant or Appropriate Requirements (ARARs), has minimal impact on the community, and at a low cost. Alternatives 3 and 4 comprise remediation of the Selected Area of the Site to reduce the overall risk to potential trespassers identified during the human health risk assessment, and remediation of other specific areas of the Site to further reduce risks. They provide excellent overall protection, comply with ARARs, and provide excellent long-term protection. However, Alternative 3 has better short-term effectiveness because it has fewer impacts to the community, and is more cost effective than Alternative 4. Alternative 5 is similar to Alternatives 3 and 4 in terms of overall protection, compliance with ARARs, and long-term effectiveness. However, this alternative will have the greatest impact on the community, and destroys the existing habitat at the Site, replacing it with a new habitat (grasslands) that did not occur naturally at the Site. Alternative 5 is also substantially more expensive than any other alternative.

Based on the results of prior screening of remedial options, the following four Remedial Alternatives for groundwater were evaluated in this FS:

1) No Action;
2) Source Control and Monitoring;
3) Biological Treatment and Monitoring; and,
4) Chemical Treatment and Monitoring.

The following table summarizes the characteristics of each Groundwater Remedial Alternative when compared to USEPA's evaluation criteria.

Evaluation Criteria	**Groundwater Alternatives**			
	1	**2**	**3**	**4**
Overall Protection of Human Health and the Environment	Poor	Good	Good	Good
Compliance with ARARs	Poor	Excellent	Excellent	Excellent
Long-Term Effectiveness and Permanence	Poor	Moderate	Good	Good
Reduction of Toxicity, Mobility, and Volume Through Treatment	Poor	Moderate	Good	Good
Short-Term Effectiveness	NA	Excellent	Excellent	Good
Implementability	NA	Excellent	Good	Moderate - Good
Costs	$0	$1,298,000	$1,814,000 to $2,292,000	$2,971,000 to $4,128,000

NA - Not Applicable
For Groundwater Alternatives 3 and 4, the range of costs reflects differing remedial approaches included within the alternative.

Alternative 1, No Action, provides the least protection but has no implementability concerns and no cost. Alternative 2 comprises source control and groundwater monitoring; it provides good overall protection and excellent compliance with ARARs, low community impacts, excellent implementability, and is cost effective. Alternatives 3 and 4 are similar in that they include biological treatment (Alternative 3) or chemical treatment (Alternative 4) followed by groundwater monitoring. Similar to Alternative 2, they provide good overall protection and excellent compliance with ARARs. However, Alternatives 3 and 4 will be subject to implementation concerns due to the nature of the landfilled materials, and have a much higher cost than Alternative 2.

1. INTRODUCTION

On behalf of Chevron Environmental Management Company for itself and on behalf of Kewanee Industries, Alcatel-Lucent USA, Inc., and Novartis Pharmaceuticals Corporation (collectively, the Group), Geosyntec Consultants (Geosyntec) has prepared this Feasibility Study Report (FS Report) for the Rolling Knolls Landfill Superfund Site (the Site) in Chatham, New Jersey. The purpose of this FS Report is to evaluate remedial alternatives for soil and groundwater based upon the remedial action objectives (RAOs) for the Site, and to conduct a detailed analysis of these alternatives based upon nine screening criteria, including effectiveness, implementability, cost, and several other factors.

The Site location is shown in Figure 1-1, and the Site features are shown in Figure 1-2. The Group executed the Administrative Settlement Agreement and Order on Consent (Agreement) (Index No. II-CERCLA-02-2005-2034) with the United States Environmental Protection Agency (USEPA) in 2005. Between 2005 and 2007, investigation workplans were prepared and submitted to USEPA for review and approval. Beginning in 2007, the Group conducted field investigation activities in accordance with USEPA-approved work plans.

The remainder of this report includes:

- A discussion of Site conditions and results of Site investigations (Section 2);
- The results of human health and ecological risk assessments (Section 3);
- A summary of the constituents of concern (COCs), a discussion of risk-based and Site use-based evaluations, and the presentation of the Applicable or Relevant and Appropriate Requirements (ARARs), RAOs, and Preliminary Remediation Goals (PRGs) (Section 4);
- The development of soil and groundwater remedial alternatives (Section 5);
- Detailed Analysis of Soil Remedial Alternatives (Section 6);
- Detailed Analysis of Groundwater Remedial Alternatives (Section 7);
- Summary and Conclusions (Section 8); and,
- References (Section 9).

2. SITE BACKGROUND

2.1 Site Description

The Site location is shown in Figure 1-1, and the Site features are shown in Figure 1-2. The Site is located at the southern end of Britten Road in the Green Village portion of Chatham Township. Green Village is a scenic, rural village oriented along Green Village Road. Green Village Road is a 2-lane (one in each direction) county road with residential and limited commercial development on each side. Britten Road intersects Green Village Road and is primarily residential. Britten Road is approximately 1.5 lanes wide and is the only road that provides access to the Site. The Site is approximately 5.5 miles from the nearest major road, State Route 24, and is accessible only by driving through residential and commercial areas of Chatham.

The Site is located within the Piedmont Physiographic Province which is characterized by a low rolling plain that is divided by a series of higher ridges. The topography in the vicinity of the Site is approximately 240 feet above mean sea level (amsl) with minor fluctuation in topographic relief.

The Rolling Knolls Landfill covers approximately 170 acres, including one area of approximately 140 acres with a layer of waste material (18 feet or less in thickness) overlying native soil and a second area of approximately 30 acres with isolated areas of debris on the surface, referred to as the Surface Debris Area (Figure 1-2). The landfill was used for disposal of municipal waste from Chatham Township and nearby municipalities from the 1930s to approximately 1968. Landfilled materials were generally consistent with typical municipal solid waste expected within a landfill operating during this period. Evidence of potential industrial waste, identified based on visual observations and analytical results, were observed at three isolated areas, comprising only a small proportion of the total volume of waste disposed of at the landfill. The landfill is covered in some areas by a thin layer of soil and/or vegetation, and in others the waste is visible at the surface. Historical operations of the landfill included the application of pesticides for mosquito and rodent control on the landfill and the surrounding area.

Wetlands occupy the adjacent areas to the east, south, and west of the Site. Loantaka Brook and residential properties are located to the west. Black Brook and the Great Swamp National Wildlife Refuge (GSNWR), including a designated Wilderness Area, borders the Site to the south and east. GSNWR includes a portion of the landfill, as discussed below.

GSNWR was established in 1960 and encompasses 7,768 acres of varied habitats, including wetlands, uplands, and aquatic areas; 35 acres of the landfill are within the GSNWR (Fish and Wildlife Service, 2016). The eastern portion of the GSNWR comprises the 3,660-acre Wilderness Area. More than 244 species of birds have been identified at GSNWR, as well as a wide range of native mammals (for example, river otter, mink, red fox, and opossum), fish, amphibians and reptiles. Several endangered species, including Indiana bat, bog turtle, and blue-spotted salamander are also found at the GSNWR (Fish and Wildlife Service, 2016).

2.2 Current and Future Site Use

Two landscaping companies rent areas on the landfill and the Surface Debris Area for equipment storage and maintenance. A small area, known as the laydown area is located on the privately owned portion of the Site. Chatham Disposal and South Orange Disposal, both of which are municipal waste hauling companies owned by members of the Miele family, use this area for the storage and staging of empty solid waste roll-off bins. A small building known as the Hunt Club is located on the Surface Debris Area and is used infrequently for social functions. Hunters formerly used the landfill from time to time but are no longer observed. A Shooting Range and Baseball Field are located north of the landfill on land owned by the Green Village Fire Department (GVFD) and are used infrequently for recreation.

The operations currently ongoing within the landfill (the Hunt Club, two landscaper areas, and the storage of roll offs) will not continue except as noted below. With the GSNWR located both on and adjacent to the Site, maintenance of the Site in an undeveloped condition provides a buffer between the developed areas of Chatham Township and the GSNWR. The presence of wetlands, the flood hazard area and habitat for state- and federally-listed endangered species severely limits Site use. Accordingly, the environmental characteristics and associated regulatory restrictions and other impediments to development (TRC, 2017) make open space/preservation the likely anticipated future use of the Site. The GSNWR is already a preserve and the Miele Trust is willing to allow engineering and institutional controls to restrict use of and access to the portion of the Site that it owns. The small portion of landfill on the GVFD property is not eligible for development. As a result, there will be no residential, commercial, industrial, recreational, or any other use of the landfill portion of the Site.

Based on the results of the RI, the Baseball Field and Shooting Range were found to be outside the landfill boundary and are not impacted by the waste materials. These areas may be used for recreational purposes in the future. The Miele Trust may continue to allow use of a portion of the property that is outside the landfill boundary as a laydown area, to the extent USEPA consents to this use.

2.3 Site Ownership

The central and western portions of the landfill, including the Surface Debris Area (shown on Figure 2-1), are owned by the Trust created by the Last Will and Testament of Angelo J. Miele (Miele Trust). We have been advised that Paul Miele is the current Trustee of the Trust. The Trust owns approximately 100 acres of the landfill, plus the adjacent Surface Debris Area of approximately 30 acres. A small area at the northern end of the Surface Debris Area, approximately 4,000 square feet but not surveyed, extends onto a private residential property. A portion of the Site as defined by USEPA for purposes of the RI/FS is on land owned by the GVFD, including approximately 5 acres of the landfill, and areas north of the landfill that are currently used as a Baseball Field and Shooting Range. There is no evidence that landfilling occurred in the Baseball Field or Shooting Range or that these areas have been adversely impacted by waste disposal elsewhere on the Site. The remainder of the landfill (approximately 35 acres) is owned by the United States Fish and Wildlife Service (USFWS).

2.4 Site History

The Rolling Knolls Landfill reportedly operated from the 1930s until the late 1960s. The landfill was closed in December 1968. Wastes that were disposed of at the landfill during its operation included primarily municipal solid waste as well as a limited amount of industrial wastes and construction and demolition debris generated by the surrounding municipalities (including: Summit, South Orange, Madison, Harding, Chatham Township, Chatham Borough, Berkeley Heights, Warren, Morristown, Millburn, Florham Park, Long Hill, New Providence, Maplewood, and the County of Morris). The regulations imposed by the Chatham Township Board of Health (CTBH) during and after the operation of the landfill included requirements for weekly inspections, the application of minimal daily cover (i.e., "swamp muck"), rodent and mosquito control, and drainage of stagnant surface water (Arcadis, 2012). CTBH records also referenced the application of herbicides, oil (as a dust control measure), chemical sprays (for rodent control), the disposal of dead animals, and for a period of time, disposal of septic wastes (Arcadis, 2012).

In 1964, the United States acquired 300 acres of land from the North American Wildlife Federation. A portion of that land was subject to an easement pursuant to which the United States permitted the Miele Trust to conduct sanitary landfilling operations on the acquired property through December 31, 1968. Landfilling operations appear to have been conducted on approximately 35 acres of this property, which became part of the GSNWR. In 1969, Chatham Township contacted the United States about its plans to comply with Chatham Township ordinances regarding closure of the landfill. The United States responded that "Mr. Miele" and not the United States was responsible for closure and that the United States would contact Mr. Miele and report back to Chatham. There is no evidence in the record that this ever happened. A fire occurred at the Site in 1974, and due to accessibility issues in responding to the fire, the Trust was permitted to construct fire roads at the Site, which it did from 1979 to 1982. In January of 1975, Chatham Township again contacted the United States. Chatham noted that the portion of the landfill that the United States owned was never properly covered and requested the United States' plans for final cover and other actions to avoid future fires. In response, the United States acknowledged that the portion of the landfill on its property was never properly closed but advised Chatham that it had no plans to cover the landfill, that covering it might cause more damage than leaving it alone, and with respect to the possible leaching of pollutants from the landfilled waste, "nature should now be allowed to take its course." The fire roads that the Trust constructed consist of imported material, including construction and demolition debris, and are approximately 4 feet higher than the surrounding landfill surface (Arcadis, 2012).

2.5 Previous Investigations

Contractors to USEPA conducted several investigations at the Site between 1985 and 2003. The work included collection and analysis of soil, sediment, and surface water and fish tissue samples. In addition, these investigations included installation and sampling of seven monitoring wells. Six of these monitoring wells are still in use.

The results of these investigations were used by USEPA in the initial evaluation of the Site. However, they have been superseded by the results of the investigations conducted by the Group since the Administrative Consent Order was executed.

2.6 Implementation of the Remedial Investigation

The Remedial Investigation (RI) was conducted in two major phases. The first phase was planned and implemented from 2005 through 2011, with the general objectives of (1) characterizing the geology and hydrogeology at and in the vicinity of the landfill; (2) characterizing the waste in the landfill including its contents and extent; (3) characterizing COCs in environmental media (soil, sediment, surface water, groundwater, and soil gas) at and in the vicinity of the landfill; and, (4) providing a basis for risk assessments and for remedy selection. The results of the first phase of the RI were reported in the Site Characterization Summary Report (SCSR; Arcadis, 2012).

After the submittal of the SCSR, the USEPA and the Group discussed additional work that might be needed to address data gaps at the Site to complete the RI. The overall objectives of the additional work were to (1) complete characterization of the nature and extent of COCs associated with the Site; (2) provide additional information to be used in scoping an evaluation of ecological risk; and, (3) provide additional information to be used in screening remedial alternatives and selecting a remedy for the Site. The results of the second phase of the RI were reported in the Data Gaps Tech Memo (Geosyntec, 2016a).

The Group provided a revised draft RI Report (RIR) to the USEPA in December 2017 (Geosyntec, 2017a). The USEPA is currently reviewing this revised draft RIR. The Group also conducted a supplemental groundwater investigation to evaluate the efficacy of monitored natural attenuation (MNA) as a remedial action to address constituents in groundwater at the Site. The results of this investigation were provided to USEPA in January 2017 in the Supplemental Groundwater and Baseline Monitored Natural Attenuation Investigation Report (Groundwater MNA Report; Geosyntec, 2017b). USEPA approved this report in October 2017.

In connection with USEPA's nationwide directive to ensure that RAOs reflect reasonably anticipated future land uses, the Group conducted a reuse assessment to evaluate Site-specific, reuse-related considerations to identify reasonably anticipated future Site uses. The results of this assessment were provided to USEPA in February 2017 in the Reuse Assessment Report (TRC, 2017a) and supplemented in a Reuse Assessment Addendum provided to the USEPA in April of 2017 (TRC, 2017b). The Reuse Assessment Addendum concluded that the potential reuse of the Site is severely limited by (1) the presence of extensive and state- and federally-regulated areas that limit development; (2) the environmentally sensitive nature of the surrounding area; (3) state, county, and local planning documents that discourage development in environmentally-sensitive areas away from established centers and focus on protection of the GSNWR; (4) the lack of available infrastructure and associated Site accessibility issues; and, (5) the presence of buried waste which complicates construction and makes it costlier.

The following summary of the RI results is based on information in the draft RIR and in the Groundwater MNA Report.

2.7 RI Results

2.7.1 Soil

Approximately 240 soil samples were collected in shallow soil within and near the landfill footprint. The depths of these samples were generally 0.0 to 1.0 feet below ground surface (bgs), but some were as deep as 1.5 to 2.0 feet bgs if the shallower intervals did not contain enough soil to sample. Most were analyzed for full Target Compound List and Target Analyte List (TCL/TAL) constituents. A subset of the samples was also analyzed for dioxins, furans, and polychlorinated biphenyl (PCB) congeners.

Surface and subsurface soil impacts were identified across the landfill, including semi-volatile organic compounds (SVOCs), PCBs, pesticides and inorganic constituents (i.e. metals, most frequently lead and arsenic). In general, the constituents are widespread and their distribution does not suggest a point source or sources, or discrete spills or releases. Few isolated impacts were observed in the Surface Debris Area, in the western portion of the landfill, and along the western and southwestern landfill perimeter. No waste disposal occurred and no landfill-related impacts were observed in soil at the Baseball Field and Shooting Range.

Constituent levels in soil samples obtained at or adjacent to the edges of the landfill are generally less than applicable residential soil remediation standards, providing horizontal delineation of the constituents. With the exception of one location where PCBs were detected at low levels, samples of native soil collected beneath the landfilled materials confirmed that constituents in the landfill are not present in the underlying native soil.

2.7.2 Sediment and Surface Water

Surface water and sediment sampling was conducted in the on-Site ponds and in Loantaka Brook and Black Brook both upstream and downstream of the Site. Surface water and sediment in the ponds and downstream portions of Loantaka Brook and Black Brook exhibit some constituents that are found at the Site. These constituents, with the exception of several metals, naphthalene, and acetone, are also found in surface water and sediment upstream of the Site. Therefore, their presence in the streams appears to be related to natural background concentrations, anthropogenic inputs from upstream of the landfill or discharge of groundwater high in trace elements to surface water. With the exception of a low level of dibenz(a,h)anthracene marginally above its ARAR, the constituents are not found in the most downstream surface-water and sediment samples, confirming that the downstream extent of constituents potentially related to the Site, if any, has been defined.

2.7.3 Groundwater

The discussion in this section includes results and conclusions from both the RIR and the approved Groundwater MNA Report. The groundwater zone of interest at the Site is the shallow water-bearing zone comprising silt and sand located below the landfilled materials, with a maximum depth of approximately 25 feet bgs. Because it is nearest to the potential sources of contamination in the overlying landfilled materials, the groundwater investigation has been focused on this shallow zone. Although the shallow aquifer is identified by New Jersey as a Class 2A potable aquifer, it is not currently used nor is it practically available for drinking water because under New Jersey Department of Environmental Protection (NJDEP) regulations (N.J.A.C. 7:9D-2.3) potable wells must have a well casing that is at least 50 feet deep. However, the NJDEP's classification still applies to the Site and remediation will be completed to meet the state and federal standards. The clay layer beneath the shallow water-bearing zone is at least 25 feet thick beneath the Site and reportedly more than 100 feet thick in the Site vicinity (Minard, 1967). The clay layer serves as a barrier to the vertical migration of contamination.

Other than inorganic constituents, the RI concluded that concentrations of COCs above their New Jersey Ground Water Quality Standards (GWQS including the Interim Ground Water Quality Criteria [IGWQC] which the NJDEP enforces as groundwater standards), are localized with no overall dissolved groundwater plume. Four areas of impacted groundwater were identified in the shallow water-bearing zone. These include:

- Benzene and 1,4-dioxane in the southwestern part of the landfill. These constituents were found in monitoring well MW-3 and certain of the nearby temporary well points, and are located downgradient of test pit TP-09, where evidence of potential industrial waste was observed (Figure 2-2). The downgradient extent of benzene is defined by monitoring well MW-15, which did not contain benzene. 1,4-Dioxane is present in monitoring well MW-15, but at a much lower level than in well MW-3. The decreases in benzene and 1,4-dioxane concentrations from well MW-3 to downgradient well MW-15 indicates natural attenuation of these constituents. Certain polyaromatic hydrocarbons (PAHs), including 2-methylphenol, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, bis(2-chloroethyl)ether, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and pentachlorophenol were also found in temporary well points in this area. Of these, only bis(2-chloroethyl)ether was also detected in a monitoring well (MW-3).
- Monitoring wells MW-6 and MW-7 within the landfill historically contained 1,4-dioxane above the GWQS. During the most recent round of sampling, 1,4-

dioxane was analyzed using the currently recommended method (Method 8270 with selective ion monitoring), resulting in the lowest possible detection levels. As reported in the MNA Report (Geosyntec, 2017b), MW-6 could not be sampled in the most recent sampling event in September 2016; however, the MW-7 concentration remained at a similar level as prior sampling events. Monitoring wells X-1 and X-2, downgradient of MW-7 did not contain detectable concentrations of 1,4-dioxane, indicating the extent of 1,4-dioxane is limited.

- Freon compounds (including dichlorodifluoromethane and trichlorofluoromethane) in the northwestern portion of the landfill and the Surface Debris Area. These constituents were found in monitoring wells MW-10, MW-18, and certain of the nearby temporary well points, and are located near point of interest POI-10, where refrigerators were observed on the ground surface (Figure 2-2). This area is directly adjacent to wetlands. The downgradient extent of the Freon compounds is defined by two pore-water samples collected in the wetlands. The most recent groundwater sampling event did not detect these compounds at concentrations above the GWQS.
- PCBs detected historically at monitoring well MW-7 in the east-central portion of the landfill. PCBs were not detected in nearby and downgradient monitoring wells so these impacts are confined to this specific area in the immediate vicinity of MW-7. In addition, PCBs were not detected in the most recent sample at this well, collected in September 2016.
- Benzene at monitoring well MW-19 near the southeastern boundary of the landfill. The benzene concentration at MW-19 only marginally exceeds the applicable standard. The extent of benzene in this well is defined by two downgradient pore-water samples obtained in the wetlands, which did not contain benzene.

Inorganic constituents were ubiquitous in the monitoring well samples. Inorganic constituents are common in groundwater within this region of New Jersey. While it is understood that the landfill may contribute to concentrations of these inorganic constituents in groundwater, discerning between contributions from the landfill and natural background concentrations of these constituents is difficult because the concentrations at the Site are similar to background. Therefore, although some inorganic constituents are present in groundwater at concentrations above their GWQS, their occurrence is widespread and does not suggest a distinctive source or release.

Concentrations of dissolved metals (i.e., the results of filtered samples) are generally much less than the concentrations of total metals. This indicates that most of the metals detected are associated with colloids in the samples, however, elevated metals results do not appear to be consistently related to colloids. The concentration of metals in the aquifer underneath the landfill decreases as groundwater flows to downgradient areas. This is likely related to geochemical conditions in the aquifer: strongly reducing beneath the landfill, leading to the formation of sulfide minerals, and oxidizing outside the landfill, leading to immobilization of metals in oxidized forms. Depending on the selected Remedial Alternative for groundwater, additional monitoring wells may be installed to verify whether these conditions are widespread across the Site.

In summary, contaminant concentrations in groundwater are generally low, other than at well MW-3. Historical data indicate that the benzene and 1,4-dioxane concentrations in MW-3 are decreasing (Geosyntec, 2017b). The current monitoring network indicates that the impacts are confined to areas immediately below the landfill with little migration away from the landfill. Groundwater will not be used on the Site in the future and there are no downgradient receptors for groundwater.

2.7.4 Indoor Air

Sub-slab soil gas was collected from beneath the Hunt Club building, a small generally unoccupied building that is used occasionally for social functions. The small number of volatile compounds detected in soil gas and their low concentrations below regulatory action levels confirm that soil gas beneath the Hunt Club building is not a potential indoor air threat.

3. RESULTS OF RISK ASSESSMENTS

3.1 Baseline Human Health Risk Assessment

A Baseline Human Health Risk Assessment (BHHRA; CDM, 2014) was prepared for the Site based on the results in the SCSR. USEPA subsequently evaluated the results of the BHHRA during 2016 to determine the impact of the sampling results obtained after the SCSR, and confirmed that the conclusions of the 2014 BHHRA were still valid. The results discussed herein are from the 2014 BHHRA.

The focus of the assessment was to characterize potential exposure, cancer risks and non-cancer health hazards to potential human receptors at the Site if no remedial actions are taken to address environmental impacts that are present. The objective of the BHHRA is to provide information to support Site-specific risk management decisions when evaluating and selecting remedial action approaches and options. The BHHRA is supported by information included in a *Revised Technical Memorandum on Exposure Scenarios and Assumptions* (MESA) and a *Pathway Analysis Report* (PAR), both of which were approved by the USEPA (Arcadis, 2008 and 2013a). The MESA detailed exposure scenarios, potential receptors and receptor-specific exposure assumptions that were used to evaluate potential human health cancer risk and/or non-cancer health hazards. The subsequent PAR identified chemicals of potential concern (COPCs), Site-specific exposure assumptions, and toxicological data used in the evaluation of potential risks and hazards to receptors at the Site. The resulting BHHRA incorporates Site setting characteristics, exposure scenarios, potential receptors, and receptor-specific exposure assumptions as well as the COPC, Site-specific exposure assumptions, and toxicological data when presenting the characterization of exposure, risk, and possible hazards to potential receptors at the Site. The reader should refer to the BHHRA itself for a complete description of methods and results.

3.1.1 Exposure Assessment

The BHHRA evaluated two exposure scenarios: the Current and Reasonably Anticipated Future Exposure Scenario and the Future On-Site Residential Exposure Scenario.

Current and Reasonably Anticipated Future Use Scenario

Receptors in the current and reasonably anticipated future exposure scenario with potentially complete exposure pathways include:

- A landscaper in Landscaper Area 1
- A landscaper in the Hunt Club Area and Landscaper Area 2
- A Hunt Club user at the Hunt Club and Landscaper Area 2
- An adolescent and/or adult shooting range user at the Shooting Range
- A ball player on the Baseball Field
- An adolescent and/or adult trespasser on the Landfill
- An adolescent and/or adult hunter on the Landfill

Future On-Site Residential Development Scenario

Although it did not characterize residential development as a reasonably anticipated future use, the BHHRA evaluated the receptors with potentially complete exposure pathways should the future Site use include a residential development: 1) a child and/or adult resident in the potentially developable area (defined as the landfill areas outside the GSNWR, potential bog turtle habitat, potential wetlands and related transition area, and potential FHA); and, 2) a construction worker in the potentially developable area.

Since the completion of the BHHRA, the Group and the Miele Trust have negotiated an agreement to restrict the Site from future residential use; therefore, risks identified in the BHHRA in the residential use scenario no longer apply to the Site.

3.1.2 BHHRA Results

Potential health risks to receptors in each exposure scenario were quantified for cancer risk, non-cancer health hazard and lead exposure. The risk characterization results are as follows:

Current and Reasonably Anticipated Future Exposure Scenario

Receptors	Cumulative Cancer Risk RME[1]	CTE[2]	Cumulative Non-Cancer Health Hazard RME	Target Organ HIs[3] > 1	CTE	Target Organ HIs > 1
Landscaper (Landscaper Area 1)	$6x10^{-5}$	$1x10^{-5}$	**2**	None	1	None
Landscaper (Hunt Club & Landscaper Area 2)	$5x10^{-6}$	$1x10^{-6}$	0.1	None	0.09	None
Hunt Club User (Hunt Club & Landscaper Area 2)	$2x10^{-6}$	$3x10^{-7}$	0.04	None	0.02	None
Adolescent Shooting Range User (Shooting Range)	$5x10^{-8}$	$4x10^{-8}$	0.002	None	0.002	None
Adult Shooting Range User (Shooting Range)	$1x10^{-7}$	$3x10^{-8}$	0.003	None	0.003	None
Ball Player (Baseball Field)	$2x10^{-7}$	$5x10^{-8}$	0.002	None	0.002	None
Adolescent Trespasser (Landfill)	$8x10^{-5}$	$1x10^{-5}$	**6**	Eye, Immune System, Nails	0.9	None
Adult Trespasser (Landfill)	$1x10^{-4}$	$6x10^{-6}$	**4**	Eye, Immune System, Nails	0.7	None
Adolescent Hunter (Landfill)	$4x10^{-6}$	$3x10^{-6}$	0.4	None	0.3	None
Adult Hunter (Landfill)	$9x10^{-6}$	$2x10^{-6}$	0.3	None	0.2	None

Notes
1 RME – Reasonable Maximum Exposure
2 CTE – Central Tendency Exposure
3 HI – Hazard Index

Individual constituent and cumulative Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) cancer risk and non-cancer health hazard estimates for adolescent and adult shooting range users at the Shooting Range and the ball player at the Baseball Field are less than USEPA target values (cancer risk of $1x10^{-4}$ to $1x10^{-6}$ and non-cancer health hazard of unity [1]), and therefore, are considered negligible.

Individual constituent and cumulative RME and CTE cancer risk estimates for the landscaper in the Hunt Club/Landscaper Area 2, the Hunt Club user in the Hunt Club/Landscaper Area 2, and adolescent and adult hunters on the landfill are within or less than the USEPA range of acceptable risks. Individual constituent and cumulative RME and CTE non-cancer health hazard estimates for these receptors are less than the USEPA target value of 1, and therefore, are considered negligible.

Individual constituent and cumulative RME and CTE cancer risk estimates for the landscaper in Landscaper Area 1 are within the USEPA range of acceptable risks. The cumulative RME non-cancer health hazard estimate for the landscaper in Landscaper Area 1 is slightly greater than the target value of 1; however, individual target organ hazard indices (HIs) for this receptor are each less than or equal to 1. Therefore, potential hazards to this receptor are likely negligible. In addition, individual and cumulative CTE non-cancer health hazard estimates for this receptor are less than the target value of 1.

Individual constituent and cumulative RME and CTE cancer risk estimates for the adolescent and adult trespassers are within the USEPA range of acceptable risks. Individual and cumulative RME and CTE non-cancer health hazard estimates for the adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. PCBs are the primary non-cancer health hazard drivers for these receptors.

Potential exposure of receptors in the Current and Reasonably Anticipated Future Exposure Scenario to lead was evaluated using the USEPA Adult Lead Methodology (ALM).

Exposure Scenarios and PbB Receptors µg/dl	**Lead Model**	**Probability of Exceeding 10**
Landscaper (Landscape Area 1)	ALM	0.5%
Adolescent Trespasser (Landfill)	ALM	3%
Adult Trespasser (Landfill)	ALM	3%

µg/dl – micrograms per deciliter

The estimated probability of fetal blood lead concentration (PbB) exceeding the target PbB is less than 5 percent for the landscaper in Landscaper Area 1 and adolescent and adult trespassers on the landfill. Potential adverse health effects associated with exposure to lead for these receptors are thus not expected.

Lead was not identified as a COPC at the Hunt Club Area and Landscaper Area 2, the Shooting Range or Baseball Field, so receptors in these human use areas were not evaluated for potential lead exposure. Furthermore, exposures to adolescent and adult hunters on the landfill are assumed to occur for only a 1-week period during hunting season in December of each year. Therefore, it is assumed that PbB in these receptors do not reach steady state (i.e., lead is cleared from the blood following brief exposure). Potential adverse health effects associated with exposure of lead to adolescent and adult shooting range users, ball player and adolescent and adult hunters is not expected.

Future On-Site Residential Development Exposure Scenario

Individual and cumulative RME and CTE cancer risk estimates for the child resident are greater than the upper end of the USEPA range of acceptable risks ($1x10^{-6}$ to $1x10^{-4}$), and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value of 1. Individual and cumulative RME and CTE cancer risk estimates for the adult resident are greater than the upper end of the USEPA range of acceptable risks ($1x10^{-6}$ to $1x10^{-4}$), and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value. Cancer risk and non-cancer health hazard drivers are PAHs, dieldrin, PCBs, dioxins and furans, and inorganics (antimony, arsenic, iron, thallium, and vanadium) in soil and benzene, dichlorodifluoromethane, 1,4-dioxane, vinyl chloride, PAHs, bis(2-chloroethyl)ether, pentachlorophenol, and inorganics (arsenic, iron, manganese, and thallium) in groundwater.

Residential exposure can be expressed as a lifetime exposure of 30 years. When adult residential exposures (estimated for 24 years) and child residential exposures (estimated for 6 years) are summed together to evaluate a potential residential lifetime exposure, the estimated cumulative residential lifetime RME excess lifetime carcinogenic risk (ELCR) is $3x10^{-3}$, which is greater than the upper end of the USEPA range of acceptable risks. When summed, the estimated cumulative residential lifetime CTE ELCR is $1x10^{-3}$.

Individual and cumulative RME and CTE cancer risk estimates for the construction worker in the Potentially Developable Area are within the USEPA range of acceptable risks, and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value. Non-cancer health hazard drivers are PCBs and cadmium in surface and subsurface soil.

Potential exposure to lead of a future child resident in the Potentially Developable Area[2] was evaluated using the USEPA Integrated Exposure Uptake Biokinetic model. The resulting probability distribution may be interpreted as an 81 percent probability of exceeding the PbB threshold of 10 μg/dl for a future child resident in the Potentially Developable Area. Potential exposure to lead of a construction worker in the Future On-Site Residential Development Exposure Scenario was evaluated using the USEPA ALM. The estimated probability of the construction worker's fetal PbB exceeding the target PbB of 10 μg/dl is 17 percent. Both scenarios exceed the USEPA risk reduction goal of 5 percent for CERCLA sites.

3.1.3 BHHRA Summary

Estimated cancer risks to all receptors and non-cancer health hazard to the majority of receptors in the Current and Reasonably Anticipated Future Exposure Scenario are within or less than USEPA target levels. The estimated non-cancer hazard to the landscaper in Landscape Area 1 is slightly greater than the USEPA target level, but HIs for individual target organs are all less than or equal to the USEPA target level of 1. Estimated non-cancer health hazard to the adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. Estimated cancer risks and non-cancer health hazards to receptors in the Future On-Site Residential Development exposure scenario are greater than USEPA target levels.

Overall, carcinogenic ELCRs and non-carcinogenic HIs presented in the BHHRA are based upon conservative assumptions that are intended to be protective of human health by overestimating exposure to account for parameter uncertainty. Therefore, overall confidence in the risk assessment is high.

3.2 Baseline Ecological Risk Assessment

A Baseline Ecological Risk Assessment (BERA; Integral, 2016a) was prepared for the Site and is based on results available through August 2016. The draft BERA report was submitted to USEPA in September 2016 and revised in accordance with USEPA

[2] Note that USEPA is updating the BHHRA to incorporate new guidance for the assessment of risks associated with lead.

comments, and resubmitted to USEPA on December 28, 2016. USEPA approved the BERA by email dated December 29, 2016. The remainder of this subsection summarizes the results of the BERA (Integral, 2016a).

The objective of the BERA was to assess potential risks to ecological receptors from exposure to Site-related COCs present in environmental media at the Site. The BERA relied on the analytical results of the previous investigations. Supplemental sampling designed to support the BERA was conducted in May and June 2016. This 2016 sampling included collecting sediment sampling for bioavailability evaluation and acute toxicity testing, collecting biota representative of forage or prey items for the evaluated receptors, and collection of environmental media from an off-Site reference pond. An ecological habitat assessment was also performed at representative portions of the Site.

The BERA is the final three steps of the eight-step process defined in the *Ecological Risk Assessment Guidance for Superfund* (ERAGS). This phased approach includes increasingly sophisticated levels of data collection and analysis. The BERA builds on two prior documents: the *Screening Level Ecological Risk Assessment* (SLERA; Arcadis 2013b) which provided ERAGS Steps 1 and 2, and the *BERA Work Plan* (Integral, 2016b), which addresses ERAGS Steps 3 through 5.

3.2.1 BERA Methods

The chemicals of potential ecological concern (COPECs) were identified as part of ERAGS Step 3 in the *BERA Work Plan*. Media were screened independently, and an aggregated collection of COPECs across all sampled media was developed. These included several SVOCs (e.g., PAHs, phthalates), PCBs, dioxins and furans, and several inorganics. The COPECs include chemicals related to Site use and others that are present naturally in the environment (e.g., metals).

Thirteen assessment endpoints were evaluated in the BERA, including:

- Terrestrial vegetation;
- Benthic invertebrates;
- Amphibians and reptiles;
- Herbivorous birds;
- Piscivorous birds;
- Herbivorous mammals;
- Vermivorous mammals;

- Vermivorous birds;
- Carnivorous mammals;
- Insectivorous mammals;
- Insectivorous birds;
- Carnivorous birds; and,
- Piscivorous mammals.

Empirical data for the COPECs from on-Site sampling were available for surface water, sediments, soil, soil invertebrates (earthworms and centipedes/millipedes), forage fish, tadpoles and aquatic vegetation. COPEC concentrations for aquatic invertebrates, emergent insects, and terrestrial vegetation were estimated using literature uptake factors (sediment or soil to biota). The use of uptake factors from literature sources is conservative and overestimates the potential exposure (and calculated risk) because it does not reflect Site-specific bioavailability from the soil or sediment. Risks were evaluated on a Site-wide basis, by basic habitat types (terrestrial, wetland, or aquatic) and by sub-habitat areas (e.g., West Pond #1, southern wetland).

3.2.2 BERA Results

The BERA results for each receptor are discussed below. The hazard quotient (HQ) was calculated based on Toxicity Reference Values (TRVs) used to assess potential risks for all receptors other than terrestrial vegetation, benthic invertebrates, and amphibians and reptiles. The approach taken for each of these receptors is explained with their results.

Terrestrial Vegetation: The SLERA showed that plant toxicity-based soil benchmarks were exceeded throughout the Site. However, the BERA established that the SLERA may have overestimated the potential risks to plants, since there was little apparent impact to vegetation that can be related to soil COPEC concentrations based on the ecological habitat survey results. The more relevant factors affecting the presence of terrestrial vegetation were (1) the thickness of the soil layer, and (2) whether solid waste was present on the surface. There were several areas of the Site, predominantly within the perimeter wetlands, that are high-value habitats, such as those associated with potential bog turtle habitats. *Phragmites* stands were noted at several locations within and adjacent to the Site and appear to be invading some of the potential bog turtle habitats. Based on the results of the BERA there is no unacceptable risk to terrestrial vegetation from COPECs.

Benthic Invertebrates: There is a potential risk to benthic invertebrates based on the comparison of the measured sediment concentrations to conservative sediment benchmarks at some of the locations sampled in 2016. This was highly variable; for example, at one of the West Pond #1 locations, total DDx and nine metals had HQ_{sed} values greater than one, but the remaining two samples had only one COPEC (selenium) with an HQ_{sed} greater than one. The COPEC metal risks may be overestimated based on the assessment of the sediment bioavailability using the measured simultaneously extracted metals-acid volatile sulfide [SEM-AVS]/total organic carbon (TOC). This showed that potential for sediment toxicity is unlikely at these locations, except for one location at the eastern landfill perimeter at sample SED007. This sample also had the largest mean HQ_{sed} of the evaluated sediments. This sample was not evaluated for acute toxicity using *Hyalella* and chironomid bioassays, so the potential for toxicity at this location cannot be verified empirically.

For all tested locations, acute toxicity using *Hyalella* and chironomid bioassays showed no impacts on survival and only a slight potential impact on *Hyalella* and chironomid growth in one of the three samples from West Pond #1 and in both North Ponds. The difference in *Hyalella* growth relative to the Reference Pond was less than 20%, which is not considered to be significant. There was no correlation between the *Hyalella* and chironomid growth results (absolute values) to the COPEC concentrations, which implies that these affects are likely unrelated to the COPEC concentrations. Thus, there are no unacceptable risks to these receptors.

Amphibians and Reptiles: The potential risks to amphibians were evaluated by comparing observed results to sediment benchmarks, similar to one of the measurement endpoints used to evaluate benthic invertebrates. Risks are unlikely, however, since tadpoles were abundant at many of the sampling locations.

The risk characterization for the amphibians and reptiles also included a comparison to studies that evaluate the potential linkage(s) between sediment PCB concentrations and amphibian population effects. Generally, there is no conclusive linkage between sediment PCB concentrations and amphibian population effects, except possibly at sites with far greater average PCB concentrations in their sediments than what is observed at the Site. Based on this comparison, in conjunction with the lack of correlation between sediment toxicity (generally regarded as a more sensitive receptor than amphibians) and PCB levels in sediments, it is concluded PCBs present in the sediments at the Site do not present an unacceptable risk to amphibians and reptiles.

Vermivorous Birds and Mammals: The BERA indicates that there were HQ_{LOAEL} (HQ for the lowest observable adverse effect limit) values greater than one for vermivorous birds (e.g., American robins) and mammals (e.g., short-tailed shrew) that consume soil invertebrates at the Site. This risk was due chiefly to the measured metals and PCB concentrations in the soil invertebrates. The Site total PCB concentrations in soil were lower than those reported from field studies that showed no dose-response relationship between the soil (and prey) total PCBs and population metrics. This suggests that the total PCBs in the Site media may not be causing significant risks to these receptors.

Use of field-collected prey items reduces the potential to overestimate potential exposures and risks to these receptor groups. In addition, conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

Piscivorous Birds and Mammals: The BERA indicates that there is no risk to piscivorous birds (e.g., great blue heron) and a potential minimal risk to piscivorous mammals (e.g., mink) that consume the forage fish or tadpoles from the On-Site Ponds (the HQ_{LOAEL} values were less than one for the individual ponds).

Use of field-collected prey items reduces the potential to overestimate potential exposures and risks to these receptor groups. In addition, conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

Herbivorous Birds and Mammals: There is no potential risk to herbivorous birds (e.g., mallard ducks) and minimal risk to herbivorous mammals (e.g. meadow vole) based on the exposure assumptions and media concentrations that have been used for this assessment. The potential risk to the meadow vole was due chiefly to the mercury, selenium and polychlorinated dibenzo-p-dioxin/furan toxic equivalent quantity (PCDD/F-TEQ) concentrations in prey items of vole. However, the selenium risks are unlikely to be Site related because all of the Site HQ values were comparable to or less than those calculated for the reference areas.

Empirical data on aquatic vegetation and estimated concentrations in aquatic invertebrates were used to assess the potential risks to the Mallard ducks. Empirical data on soil invertebrates and estimated concentrations in terrestrial vegetation were used to assess the potential risks to the meadow voles and thus the risk is likely overestimated.

Insectivorous Birds and Mammals: There is no potential risk to insectivorous birds (e.g., tree swallow) and minimal potential risk to mammals (e.g., bats) at the Site. Exposure was predominantly from the consumption of emergent insects, whose tissue levels were estimated using bioaccumulation models. The models assume 100% bioavailability from the sediments, which is unlikely based on the elevated TOC (for organics) and reduced bioavailability for metals based on the [SEM-AVS]/TOC results.

HQ_{LOAEL} values for little brown bat were less than one across most of the Site areas, except for arsenic, barium, and methyl mercury in Wetland-east, and copper on a Site-wide and wetland-combined basis (the individual subareas were all below one). Selenium risks do not appear to be Site-related because larger HQ_{LOAEL} values were calculated in the reference areas than on-Site.

The evaluation of these receptors is the most uncertain relative to the other receptors evaluated in this BERA because of the lack of available empirical data on the principal prey group, and the assumption of 100% bioavailability from Site media in the bioaccumulation models used to estimate prey item COPEC concentrations.

Carnivorous Birds and Mammals: There is no potential risk to carnivorous birds (e.g., red-tailed hawk) and mammals (e.g., red fox) at the Site. Exposure was predominantly from the consumption of small mammals, whose tissue levels were measured.

The spatial analysis of the soil analytical data showed that the COPEC concentrations were generally higher in the terrestrial portions of the Site compared to the wetland areas. The biota data were also variable from both the terrestrial and wetland areas (fewer samples were collected from the latter) but on average there were no significant differences between the mean biota concentrations across these habitats for most of the COPECs.

3.2.3 BERA Summary

The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robins. The exposure assumptions and uptake factors used to estimate aquatic invertebrate and emergent insect COPEC concentrations, and the TRVs used to assess the potential ecological risks, include some degree of uncertainty. Uncertainties are inherent for any BERA; however, the nature and magnitude of the uncertainties depend upon knowledge regarding the use of the Site by receptors, the amount and quality of data available and assumptions used in exposure potentials and benchmarks used to assess the potential risks. Here, multiple conservative assumptions were intentionally used to take uncertainties into account. The more conservative the assumptions, the less likelihood that a HQ greater than 1.0 indicates an unacceptable risk. Accordingly, any uncertainty in this analysis would overestimate rather than underestimate potential risks, given that conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

4. REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

4.1 Calculation of Alternative Remediation Standards

The New Jersey Soil Remediation Standards (SRSs) are based upon either a residential or non-residential exposure scenario, neither of which are appropriate for the future use of the Site. To address this situation, the NJDEP allows site-specific Alternative Remediation Standards (ARSs) to be calculated (N.J.A.C. 7:26D; NJDEP, 2017). These calculations are conducted by replacing NJDEP default exposure factors with exposure factors more reflective of actual Site use, in this case, exposure to adolescent and adult trespassers. Based on these calculations, ARSs were developed for 21 COCs in the landfill, two COCs in the Shooting Range, and one COC in the Baseball Field. These ARSs replace the Non-Residential Direct Contact Soil Remediation Standards (NRDCSRSs) previously applied to these COCs. The development of the ARSs is discussed in detail in Appendix A.

4.2 Constituents of Concern

For this analysis, chemical constituents were considered COCs if (1) they were present at a concentration that was associated with unacceptable risk in the BHHRA or in the BERA, or (2) they were present at concentrations above an applicable remediation standard in a media were the risk assessments identified unacceptable risk. COCs were identified in soil and groundwater, but the risk assessments did not identify any potential risks in surface water and sediments, so no COCs have been identified for those media.

4.2.1 Soil

Analytical results in soil were compared to the NRDCSRSs and, if the NRDCSRS was exceeded, the ARSs. The following COCs have been identified.

Area	COCs	Potential Exposure Pathways
Landfill surface	Metals[1], PCBs, PAHs[2], pesticides[3]	Direct contact (human and ecological)
Surface Debris Area	Lead	Direct contact (human)

Notes:
1 – Aluminum, antimony, arsenic, cadmium, copper, lead, vanadium
2 – Acetophenone, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene
3 – Aldrin, chlordane, dieldrin, heptachlor, heptachlor epoxide

Metals, PCBs, PAHs, and pesticides were found at concentrations above the NRDCSRS and/or the ARS in surface soil samples (generally collected at no deeper than 1.0 foot bgs) on the landfill. The metals found most frequently at concentrations above their NRDCSRSs and/or ARSs were lead and arsenic. The soil COCs are present over most of the landfill but are generally not found in the adjacent soil off the landfill.

Soil results were also compared to the NJDEP's Impact to Groundwater Soil Screening Levels (IGWSSLs). IGWSSLs are screening levels intended to identify areas where COCs in soil could migrate to and impact groundwater. They are not duly promulgated regulatory standards, and thus, are not ARARs, but, rather are TBCs (To Be Considered). Concentrations of certain VOCs, SVOCs, pesticides, PCBs, and metals in soil samples exceed their default IGWSSLs. Groundwater results from the existing monitoring well network indicate that there has been limited migration of these constituents to groundwater. In addition, groundwater exceedances do not generally correlate with soil results above IGWSSLs. Therefore, no additional COCs were identified based on the IGWSSLs.

Risks for adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. In addition, risks for landscapers in Landscaper Area 1 are slightly above the USEPA target level; however, the use of the property by landscapers will cease due to the institutional controls that will be placed on the Site.

Because future use at the Site will not include residential development, risks associated with the Future On-Site Residential Development Exposure Scenario in the BHHRA were not considered in this analysis.

As indicated above, COCs are generally not found in soil samples collected off the landfill. The exception is lead, which is found in several wetlands soil and sediment samples west of the landfill, in the Surface Debris Area and between the Surface Debris Area and Loantaka Brook. Although lead concentrations exceed its NRDCSRS, no unacceptable risks were found related to lead in either the BHHRA Current or Reasonably Anticipated Future Use Scenario, or in the BERA. These lead concentrations are below the calculated ARS, with the exception of soil samples collected from POI-9 and POI-14.

4.2.2 Groundwater

Analytical results in groundwater from the shallow water-bearing zone were compared to the GWQS. The following COCs have been identified.

Area	COCs	Potential Exposure Pathways
MW-3 area (southwest portion of landfill)	Benzene, 1,4-dioxane, PAHs[1]	No current risk of exposure.
MW-6 area (central portion of landfill)	1,4-dioxane	No current risk of exposure.
MW-7 area (east-central portion of landfill)	PCBs	No current risk of exposure.
MW-10 and MW-18 area (northwest portion of landfill)	Dichlorodifluoromethane, trichlorofluoromethane, benzene, 1,4-dioxane	No current risk of exposure.
MW-19 (adjacent to southeast portion of landfill)	Benzene	No current risk of exposure.
All areas of landfill	Metals[2]	No current risk of exposure.

Notes:
1 – 2-Methylphenol, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, bis(2-chloroethyl)ether, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, pentachlorophenol
2 – Aluminum, antimony, arsenic, beryllium, cadmium, iron, lead, manganese, nickel, sodium, thallium, total cyanide, zinc

There are no potable supply wells at or near the Site. The Hunt Club supply well (designated HC-1) is screened well below the clay layer that mitigates or prevents migration from the shallow groundwater that is of interest at the Site. The well is not used for drinking water. Therefore, there is no current risk of exposure to impacted groundwater at or near the Site. Any future use of the groundwater is unlikely, and not reasonably anticipated, since New Jersey regulations require drinking water wells to have casings that are at least 50 feet deep (N.J.A.C. 7:9D-2.3). However, the NJDEP's classification still applies to the Site and the goal of remediation is to meet the state and federal standards.

Other than metals, the other COCs in groundwater appear to be in separate, relatively restricted areas. Certain of the COCs are present at levels that only marginally exceed their GWQS; including:

- bis(2-chloroethyl)ether at wells MW-3;
- 1,4-dioxane at wells MW-6 and MW-10; and,
- indeno(1,2,3-cd)pyrene at well MW-7.

Based on the observed concentrations, the extent of these COCs is likely limited.

Metals in groundwater are Site-wide. As discussed in Section 2.7.3 and in the Groundwater MNA Report (Geosyntec, 2017b), metals are not detected in most of the filtered groundwater samples, indicating that metals concentrations are present in colloidal fractions, which are not readily transported with groundwater. The concentration of metals in the aquifer underneath the landfill decreases as groundwater flows to downgradient areas. This is related to the geochemical conditions in the aquifer: strongly reducing beneath the landfill, leading to the formation of sulfide minerals, and oxidizing outside the landfill, leading to immobilization of metals in oxidized forms.

4.3 Calculation of Risk-Based Remediation Area for Soil

Based on evaluation of the soil COCs and associated risk assessment findings, dioxin-like PCBs were determined to be the primary risk driver at the Site. An evaluation of the PCB data was performed using statistical analysis to identify which area(s) of the Site required remediation to reduce the overall risk at the Site to acceptable levels. The analysis identified that the Selected Area, an approximately 25-acre area on the northern portion of the Site, requires remediation. The analysis and its conclusions are discussed in detail in Appendix B.

4.4 Applicable or Relevant and Appropriate Requirements

ARARs are summarized in Table 4-1. ARARs are defined as follows:

> "Applicable requirements are federal or state requirements that 'specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site' (National Contingency Plan [NCP] Sec 300.5). Relevant and appropriate requirements are federal or state laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site, 'address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to a particular site' (NCP Sec. 300.5)." (USEPA, 1991).

The three types of ARARs are: chemical-specific, location-specific, and action-specific. These designations are noted for each ARAR in Table 4-1. As described in a letter from Walter Mugdan of USEPA to Irene Kropp of NJDEP, dated 12 May 2010, New Jersey's SRS for direct contact (i.e., ingestion/dermal exposure) are potential ARARs, but will not be considered as ARARs if those standards are not generally applicable, but rather, can change on a site-by-site basis (Appendix C; USEPA, 2010). Based on the letter, the numerical SRSs are potential ARARs with the following exceptions: (1) the lead SRS; (2) when future site use will be limited to recreation; and (3) when SRSs are based upon the inhalation pathway. The letter further establishes that impact to groundwater soil remediation goals are not ARARs because they have not been duly promulgated as regulations.

Table 4-1 also identifies certain guidance or other documents that "may provide useful information or recommend procedures if (1) no ARAR addresses a particular situation, or (2) if existing ARARs do not provide protection" (USEPA, 1991). These documents are designated TBCs in Table 4-1.

4.5 Preliminary Remedial Action Objectives

Based on the considerations of Site conditions, results of the risk assessments, the reuse assessment and ARARs described in this section, the following RAOs have been developed for the Site.

1. Prevent or minimize current/potential future unacceptable risks to human and ecological receptors through direct contact or ingestion of contaminated soil.
2. Control or remove source areas to prevent, to the extent practicable, impacts to groundwater, sediment, and surface water.
3. Prevent to the extent practicable current and potential future unacceptable risks to human receptors through ingestion of contaminated groundwater.
4. Restore groundwater to its expected beneficial use to the extent practicable by reducing contaminant concentrations below the more stringent of federal Maximum Contaminant Levels and New Jersey GWQSs.

4.6 Preliminary Remediation Goals

The PRGs applicable to the Site are listed below by media, with the numeric criteria provided in the below referenced tables.

Soil

- Landfill area: NRDCSRSs potentially apply to this area except for 21 compounds which have an ARS, replacing the NRDCSRS (Table 4-2);
- Baseball Field area: Residential Direct Contact Soil Remediation Standards (RDCSRS) potentially apply to this area except for one compound for which an ARS was calculated (Table 4-3); and,
- Shooting Range area: RDCSRS potentially apply to this area except for two compounds for which an ARS was calculated (Table 4-4).

Groundwater

The PRGs for Site-wide groundwater are the NJDEP's GWQS as shown on Table 4-5.

5. SELECTION OF REMEDIAL ALTERNATIVES

5.1 Introduction

This section summarizes the general response actions, remedial technologies, and process options as well as the criteria and methodology used to develop the soil and groundwater remedial alternatives presented in this report. The areas requiring remediation were based on the risk-based evaluation (Section 4.3) and on comparison of soil and groundwater data to the PRGs (Section 4.6). Based upon these evaluations, the landfill is the only area with exceedances requiring remediation; the Baseball Field and Shooting Range do not require remediation and are therefore not included in the remedial alternatives. A detailed discussion of the remedial alternative development process is provided in the Technical Memorandum for the Development and Screening of Remedial Alternatives (DSRA Tech Memo) dated March 2017 (Geosyntec, 2017c).

Based upon the information discussed in the RIR, Groundwater MNA Report, BHHRA, and BERA, the Site presents many of the characteristics typical of municipal landfills – it poses a low-level threat and the volume and heterogeneity of waste make treatment impracticable. Another consideration in the identification of general response actions is that the Site is located within an environmentally sensitive area within the GSNWR. The Site is also characterized by the presence of wetlands, FHAs, and habitat areas for endangered species (the bog turtle and blue-spotted salamander). Also, Green Village is a scenic, rural village oriented along Green Village Road, but its rural character will likely be adversely impacted if development of the Site occurs (Chatham Township Planning Board, 2011). The rural nature of this area also limits access to the Site; the existing road infrastructure, e.g. Britten Road and Green Village Road, is not designed to accommodate high volumes of heavy construction equipment. These factors were considered throughout the development of the remedial alternatives, in conjunction with other screening criteria.

5.2 Identification and Screening of Technology Types and Process Options

The general response actions, remedial technologies, and process options considered were identified from Tables 2 through 5 of the *Technical Memorandum on Candidate Technologies* (TMCT; Arcadis, 2015; these tables are provided in Appendix D) as well as in response to (i) a 20 May 2015 letter sent by USEPA regarding Comments on the TMCT and (ii) comments provided by USEPA during a project meeting in Edison, New Jersey on 14 September 2016 regarding those specific technologies.

The remedial technologies and process options identified as being potentially applicable to the Site were evaluated in two phases: preliminary screening of remedial technologies and process options screening. Each process option was preliminarily screened with respect to the screening criteria, Site COCs, and other Site-specific factors. Preliminary screening was performed in consideration of guidance from Section 4.1.2.4 and Figure 4-4 of *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and previous preliminary screening results presented in Tables 2 and 3 of the TMCT.

The second phase of evaluation/screening was conducted for the process options that were retained from the preliminary screening of technologies. The evaluation/screening was based on three criteria: effectiveness, implementability, and cost. Process options were assigned ratings ranging from low to high for each category. Screening criteria for this stage of evaluation were based on guidance on the evaluation of process options presented in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and previous evaluation results presented in Tables 4 and 5 of the TMCT.

During the evaluation, the decision to retain a process option was based on the relative favorability of the evaluation ratings for each evaluation criterion and the relative benefit of a process option over a similar process option. In other words, a process option may receive favorable ratings for all three criteria, but ultimately provide less effective treatment or be less economical for similar results when compared to a similar process option.

The following Site-specific factors strongly influenced the evaluation and screening of the identified process options:

- As discussed in Section 2.2, there will be no residential, commercial, industrial, recreational, or any other future use on the landfill portion of the Site;
- Human health risks to trespassers are present in the Site soil[3];
- Minor ecological risks to shrews and robins exist in terrestrial habitat on the landfill;
- No risks for human or ecological receptors in sediment or surface water were identified in the BHHRA or BERA;

[3] Human health risks to future adult and child residents were not considered because the future use of the Site will not include residential development.

- The areal extent of the Site is large, which, limits the feasibility of certain process options due to cost and/or implementability;
- Site access for trucks and equipment is limited to Britten Road and other Chatham Township roads, which limits the feasibility/implementability of certain process options requiring a high volume of vehicle traffic;
- The Site soil is mixed with a significant amount of municipal waste, which may make some process options ineffective and/or difficult to implement;
- Potable use of Site groundwater is not reasonably anticipated in the future;
- Metals are present in the Site groundwater but do not appear to migrate away from the landfill likely due to differences in the geochemical conditions below and away from the landfill;
- The known non-metals groundwater impacts are localized and are believed to be limited to areas within and close to the boundaries of the landfill; and,
- The thick clay layer beneath the Site prevents vertical migration of COCs.

Process options were not evaluated in isolation; we considered the implementation of process options in conjunction with other process options. This allowed certain options to be retained, even if not applicable to all media or all COCs, provided they could be implemented in conjunction with other process options to provide an effective remedy, both for current and future Site uses. The following sections summarize the findings of the two phases of evaluation for soil and groundwater process options.

5.2.1 Soil

In the DSRA Tech Memo, 29 process options, grouped into 12 remedial technologies and then into nine general response actions, were evaluated for potential inclusion as a remedial alternative (Geosyntec, 2017c). Of these, 17 process options were not retained, as explained below.

- In-situ biological treatments bioventing and enhanced bioremediation were not retained for further consideration because they are not established technologies for treating a significant portion of the Site COCs (e.g., PCBs, metals). In addition, the effectiveness of bioventing is limited by shallow groundwater at the Site and the effectiveness of enhanced bioremediation is limited by heterogeneous media (e.g., soil mixed with varying types of waste) on Site.
- Treatment and reuse of contaminated soil was not retained for further consideration based on its technical implementability. To be reused on the Site, soil (actually a soil-waste mix) would require ex-situ treatment. None of the ex-

situ treatments were expected to be applicable to the waste-soil mixture present on the Site.

- The asphalt cap process option was not retained due to its higher cost relative to other low-permeability cap process options that offer the same effectiveness. Additionally, the asphalt cap process option would not allow for the preservation or restoration of natural habitat, further reducing its appropriateness for the Site.
- Slurry phase biological treatment was not retained because its implementation would offer little benefit over the off-Site disposal process option. Similarly, incineration was not retained because the inclusion of incineration prior to off-Site disposal would offer no increase in benefit as incineration is not applicable to inorganic COCs, the presence of which would still necessitate off-Site disposal of the incinerated soil.
- In-situ treatments oxidation/reduction and precipitations/co-precipitation were not retained because they are expected to be less effective than containment options and would still require containment to prevent direct contact. As such, in-situ oxidation/reduction and precipitation/co-precipitation offer no benefit over other containment process options.
- In-situ treatments including thermal treatment, cementation and/or solidification and/or stabilization, and soil vapor extraction and ex-situ treatment options including thermal treatment, chemical extraction, chemical reduction/oxidation, separation and solidification/stabilization were not retained because of anticipated low effectiveness and/or low implementability due to the heterogeneous nature of the soil-waste mixture present at the Site.
- Biopiles was not retained because of the long treatment time relative to other ex-situ biological treatments.
- Landfarming was not retained because it is not anticipated to be feasible for the large area and volume of soil requiring treatment, and because the soil is mixed with waste.

The remaining 12 process options, listed below, were retained for consideration during the development of remedial alternatives, as described in Section 5.3.

- No Action;
- Monitoring of containment technologies/cover integrity;
- Institutional controls to restrict future property use;
- Access restrictions using physical barriers, signage, and security;

- Containment via a vegetative cover to prevent direct contact with impacted material;
- Containment via a low-permeability cover to minimize infiltration and prevent direct contact with impacted material;
- Containment via a subsurface low-permeability liner to minimize infiltration or leaching into subsurface;
- Biological in-situ treatment via phytoremediation (e.g. plants that remove, stabilize, or destroy soil constituents);
- Removal via excavation of impacted material;
- Disposal/Discharge via off-Site disposal of material at an approved landfill;
- Disposal/Discharge via on-Site consolidation via excavation and relocation of soil on-Site with long-term management (e.g. containment); and,
- Disposal/Discharge via backfilling of excavation with clean fill.

5.2.2 Groundwater

In the DSRA Tech Memo, 29 process options for groundwater, grouped into 13 remedial technologies and then into eight general response actions, were evaluated for potential inclusion as a remedial alternative (Geosyntec, 2017c). Ten process options were not retained for further consideration as a result of the evaluation screening phase. The reasons for not retaining these process options are explained below.

- Trenched cutoff wall, sheet piling, permeable reactive wall, and passive/reactive treatment walls were not retained for further consideration because they are not effective options for mitigating on-Site impacts, only controlling off-Site migration of constituents, which is not an issue for the Site.

- Groundwater recovery trenches, chemical treatments with ozone, and Fenton's Reagent/hydrogen peroxide were not retained for further consideration for the Site because they were considered less effective or offer no significant benefits over, other technologies evaluated.

- Soil vapor extraction and air sparging were not retained for further consideration because they are not expected to be effective in treating the low VOC concentrations and are expected to be difficult to implement given the heterogeneous nature of the Site soil conditions.

- Advanced oxidative processes were not retained for further consideration because energy requirements, and therefore costs, of implementation are expected to be higher than comparable process options.

The remaining 19 process options, listed below, were retained for consideration during the development of remedial alternatives, as described in Section 5.3.

- No Action;
- Groundwater monitoring through the collection of groundwater samples;
- Institutional controls to restrict future groundwater use;
- MNA of impacts;
- Low-permeability cover to reduce infiltration to impacted areas and prevent direct contact with groundwater;
- Groundwater extraction to control migration of groundwater impacts;
- Chemical in-situ treatment using persulfate for oxidation of contaminants;
- Chemical in-situ treatment using permanganate for oxidation of contaminants;
- Biological in-situ treatment via enhanced reductive dechlorination (e.g. injection of a degradable substrate to enhance biodegradation of chlorinated compounds);
- Biological in-situ treatment via aerobic bioremediation (e.g. oxygen injection into the subsurface to stimulate natural processes and precipitate metals);
- Biological in-situ treatment via phytoremediation (e.g. plants that remove, stabilize, or destroy the contaminants);
- Physical ex-situ treatment via air stripping;
- Physical ex-situ treatment via carbon adsorption;
- Chemical ex-situ treatment via ion exchange;
- Chemical ex-situ treatment via precipitation;
- Disposal/Discharge via off-Site landfill;
- Disposal/Discharge via a publicly owned treatment works under a permit;
- Disposal/Discharge via reinjection of treated groundwater; and,
- Disposal/Discharge via surface water discharge.

5.3 Identification of Remedial Alternatives

This section presents Remedial Alternatives for soil and groundwater at the Site. The Remedial Alternatives were developed from process options identified and evaluated as described in Section 5.2 and address the remedial action objectives (RAOs) presented in Section 4.5.

Preliminary Remedial Alternatives were provided in the DSRA Tech Memo, compiled from the process options listed above for soil and groundwater. These remedial alternatives were developed through further evaluation of effectiveness, implementability, and estimated relative cost (Geosyntec, 2017c). Based on the results of the BHHRA and BERA, the environmental media, including surface soil, groundwater, surface water, and sediment at the Site do not pose unacceptable risks that would require remediation under current and future Site uses except to protect adult and adolescent trespassers. Therefore, the soil remedial alternatives are designed to address direct contact with soil in the trespasser scenario. Since the future use of the Site will not include any development, habitation, or use, groundwater will not be used and there will be no human exposure to groundwater. Therefore, the groundwater remedial alternatives are designed to address the NJDEP GWQSs, which are ARARs.

Alternatives presented in the DSRA Tech Memo were refined to account for soil conditions in certain areas of the Site that were not included in the Selected Area (Section 4.3 and Appendix B). These are defined below.

- Areas of Particular Concern (APCs) - areas where a shallow soil sample result is more than three times greater than the applicable ARS. The following soil sample locations are APCs: POI-9; POI-14; SS-90; SS-97; SS-103; SS-109; and SS-118 (Figure 4-1). Sample SS-109 is adjacent to test pit TP-09. Potential industrial wastes that may be source of groundwater impacts observed in nearby monitoring well MW-3 are present at test pit TP-09. Therefore, it is anticipated that remediation of soil sample location SS-109 will also include test pit TP-09.
- Mostly non-vegetated areas - areas where the existing vegetation permits access to the area and is too sparse to reduce direct contact with soil or waste, and soil sample results are greater than their ARS (Figure 4-1). Mostly non-vegetated areas were identified by USEPA and the Group based on aerial photographs and during a reconnaissance at the Site on December 1, 2017. Additional data may be required to determine whether soil sample results are greater than the ARS in each of these areas.

The refinement process resulted in the final soil and groundwater alternatives developed for the Site. These alternatives are the basis of this FS report and are listed below.

5.3.1 Soil

1. No Action (as required in USEPA,1988 and USEPA, 1991 under CERLCA as a basis for comparison with other alternatives);
2. Site Controls (i.e., Institutional Controls and Access Restrictions);
3. Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goal;
4. Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goal; and,
5. Site Controls and Capping of All Landfill Material.

5.3.2 Groundwater

1. No Action (as required in USEPA, 1988 and USEPA, 1991);
2. Source Control and Monitoring;
3. Biological Treatment and Monitoring; and,
4. Chemical Treatment and Monitoring.

A description of these alternatives and a comparison of each alternative to the nine evaluation criteria required by §300.430(e)(9)(iii) of the NCP (as discussed in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*; USEPA, 1988), is presented in Sections 6 (for soil) and 7 (for groundwater).

6. DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

This section presents the evaluation of each alternative in relation to the nine evaluation criteria required by §300.430(e)(9)(iii) of the NCP. It is aimed to identify the advantages and disadvantages of each alternative relative to one another so that the key differences can be compared. The comparative analysis includes a narrative discussion describing:

- Strengths and weaknesses relative to one another with respect to each criterion; and,
- How reasonable variation of key elements of the remedy could change their relative performance.

The purpose of the detailed analysis of remedial alternatives is to aid decision makers in selection of a site remedy. CERCLA requires that selected remedial actions:

- Be protective of human health and the environment;
- Comply with ARARs (or provide grounds for invoking a waiver);
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and,
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element (or provide an explanation in the Record of Decision [ROD] as to why it does not).

The detailed analysis presented in this section includes:

- *Description of each remedial alternative.* The description includes remedial technologies, areas, and volumes, as applicable, and a conceptual design which is used to FS level of remedial cost estimates (order-of-magnitude cost estimates having a desired accuracy of +50 percent to -30 percent). The cost estimates are based on the currently available data and knowledge of the site conditions, and therefore will be refined as more relevant information becomes available during the design phase of the selected alternative.
- *Detailed analyses of nine evaluation criteria.* As required by §300.430(e)(9)(iii) of the NCP detailed analyses were performed for the following nine evaluation criteria.
    - Threshold Criteria
      (1) Overall protection of human health and the environment: The assessment describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.

(2) Compliance with ARARs: The assessment describes how the alternative complies with ARARs or, if a waiver is required, how it is justified. The assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed are "to be considered."

- Primary Balancing Criteria

  (3) Long-term effectiveness and permanence: The assessment evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met.

  (4) Reduction of toxicity, mobility, or volume: The assessment evaluates the anticipated performance of the specific treatment technologies an alternative may employ.

  (5) Short-term effectiveness: The assessment examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of remedy until response objectives have been met.

  (6) Implementability: The assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.

  (7) Cost: The assessment evaluates the capital and operation and maintenance (O&M) costs of alternatives; a discount factor was not included in the estimates, however an inflation rate for long-term monitoring was included.

- Modifying Criteria

  (8) State (or support agency) acceptance: The assessment reflects the state's (or support agency's) apparent preferences among or concerns about alternatives.

  (9) Community acceptance: The assessment reflects the community's apparent preferences among or concerns about alternatives.

The findings from the detailed analysis of the State (or support agency) acceptance and community acceptance criteria will be presented in the ROD once USEPA completes its review of and provides comments on the final FS Report.

Each of the threshold and primary criteria is further divided into specific factors as presented in the following subsections.

6.1 Soil Alternative 1 – No Action

This alternative provides a baseline for comparing other alternatives. No remedial activities would be implemented with this alternative, so long-term human health and environmental risks for the Site will remain similar to or the same as those identified in the baseline risk assessments. There would be no additional risks posed to human health or the environment as a result of this alternative being implemented; for example, no truck traffic to increase risks of accidents or cause emissions to the atmosphere, and no impacts to the existing wildlife habitat at the Site. There are no implementability issues or concerns and no costs associated with this remedial alternative.

6.1.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* The BHHRA evaluated risks assuming no remedial actions are taken to address environmental impacts at the Site. The results of the BHHRA indicate that (i) estimated cancer risks and non-cancer health hazard to the majority of receptors in the current and reasonably anticipated future exposure scenarios are within or less than USEPA target levels, and (ii) the estimated non-cancer health hazard to the adolescent and adult trespassers on the landfill is greater than the USPEA target level.
- *Ecological Protection:* The results of the BERA indicate that, for no action, exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robin. This alternative would not, however, result in destruction of the ecological habitat.

6.1.2 Compliance with ARARs

- *Chemical Specific ARARs:* Existing concentrations of select compounds in soil exceed chemical specific ARARs. This alternative does not reduce or prevent exposure to concentrations of COCs in soil, and concentrations of COCs may not decrease naturally to meet the chemical specific ARARs.
- *Location Specific ARARs:* Location specific ARARs do not apply to this alternative because there are no remedial activities.
- *Action Specific ARARs:* Action specific ARARs do not apply for this alternative because there are no remedial activities associated with this alternative.

6.1.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* Because there are no remedial actions associated with this alternative, it is anticipated that potential future exposure to human and ecological receptors to contaminants remaining in soil will continue to pose the magnitude of risk as evaluated in the BHHRA and BERA.
- *Adequacy and Reliability of Controls*: No controls are proposed for this alternative.

6.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process Used and Materials Treated*: This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to reduce or treat soil COCs, and would not satisfy the statutory preference for treatment.

6.1.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* There are no impacts to the community with this alternative.
- *Protection of Workers During Remedial Actions:* Worker protection is not needed with this alternative.
- *Environmental Impacts:* There are no environmental impacts associated with implementation of this alternative.
- *Time Until RAOs are Achieved:* No active treatment is proposed for this alternative. The time to achieve the RAOs is undefined.

6.1.6 Implementability

- *Ability to Construct and Operate the Technology:* No remedial technology is proposed in this alternative.
- *Reliability of the Technology:* No remedial technology is proposed in this alternative.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* No alteration to the Site will be made in this alternative.
- *Ability to Monitor Effectiveness of Remedy:* No alteration to the Site and the existing monitoring network, if any, will be made in this alternative.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* No applications will be submitted to other agencies for this alternative.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* No off-Site treatment, storage, and disposal will be needed in this alternative.
- *Availability of Necessary Equipment and Specialists:* No equipment or specialists will be needed in this alternative.
- *Availability of Prospective Technology:* No remedial technology is proposed in this alternative.

6.1.7 Cost

- *Indirect Capital Cost (Design/Construction Oversight/Permits):* There is no cost to implement this alternative.
- *Direct Capital Costs:* There is no cost to implement this alternative.
- *Post-Construction Operation, Maintenance, and Monitoring Costs:* There is no cost to implement this alternative.
- *Total Costs:* There is no cost to implement this alternative.

6.2 Alternative 2 – Site Controls

This Alternative will include institutional controls and access restrictions. Site controls reduce the long-term human health risks and prevent exposure to contaminated soil by restricting land use. The institutional control will be a deed restriction and/or restrictive covenant that will preclude any further use of the landfill portion of the Site for any residential, commercial, industrial, recreational, or any other activity. As a result, there would be no Site occupants, workers, or users, and the only people that might enter the Site would be trespassers. Access restrictions will include a 7-foot high fence with signage to restrict entry to the Site by trespassers. The proposed location of the fence is shown in Figure 6-1.

There are few to no implementability issues or concerns with this alternative; USEPA has enforcement authority to require institutional controls (USEPA, 2000). Access restrictions are readily implementable. Site controls are a sustainable approach because they do not impact or require removal of the existing habitat, and result in minimal emission of carbon dioxide or other air pollutants associated with remedies that rely on trucking to haul materials to and from the Site. The relative cost for implementation of institutional controls and installation and maintenance of access restrictions is anticipated to be low.

6.2.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* Because this alternative employs controls on-Site access (fence and signage) and institutional controls which will include Site use restrictions, it is anticipated to significantly improve the protection of human health when compared to no action.
- *Ecological Protection:* This alternative does not significantly limit ecological exposures at the Site. However, the results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robin. This alternative would provide less protection against direct contact, but would also result in only limited destruction of the existing ecological habitat resulting from fence installation and maintenance.

6.2.2 Compliance with ARARs

- *Chemical Specific ARARs:* Existing concentrations of select compounds in soil exceed chemical specific ARARs. This alternative does not reduce concentrations of COCs in soils, and concentrations of COCs may not decrease naturally to meet the chemical specific ARARs. Compliance with chemical specific ARARs are summarized in Table 6-1.
- *Location Specific ARARs:* This remedial alternative will comply with Location Specific ARARs relevant to the scope of the remedial action. Compliance with location specific ARARs are summarized in Table 6-1.

- *Action Specific ARARs:* This remedial alternative will comply with Action Specific ARARs relevant to the scope of the remedial action. Compliance with action specific ARARs are summarized in Table 6-1.

6.2.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* This alternative proposes limiting access to manage residual risk from direct contact. It is anticipated that potential future exposure to human receptors to contaminants in soil will be substantially reduced with these controls in place, and thus will pose significantly lower residual risk than the magnitude that is evaluated in the BHHRA.
- *Adequacy and Reliability of Controls:* Fencing is a common technology to minimize potential direct contact by human and ecological receptors. Fencing limits access to the Site and while trespassing is possible, it is also unlikely. Institutional controls such as deed notices and restrictive covenants are reliable and durable.

6.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process Used and Materials Treated*: This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ remedial actions to reduce or treat soil COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to reduce or treat soil COCs, and would not satisfy the statutory preference for treatment.

6.2.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* This alternative will have low to moderate short-term effects on the local community. Construction of the

Site perimeter fence will result in a minor increase in traffic due to construction material, personnel, and equipment transportation to and from the Site. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site infrequently.

- *Protection of Workers During Remedial Actions:* This alternative will involve minimal disturbance of the Site soil, and the construction will be implemented in accordance with applicable Occupational Safety and Health Administration (OSHA) requirements and project-specific health and safety plan (HASP). Minimal Site disturbance and implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.
- *Environmental Impacts:* This alternative will involve minimal disturbance of the Site soils and environment for installation of the access control fence.
- *Time Until RAOs are Achieved:* No active treatment is proposed for this alternative. Therefore, the RAOs will be achieved upon completion of construction and the filing of the institutional controls.

6.2.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative proposes constructing a fence for access controls. Construction of a fence is a common technology and is straightforward. Therefore, the ability to construct and maintain the Site fence is high.
- *Reliability of the Technology:* The reliability of access controls (i.e., fencing) increases with appropriate maintenance and care. With proper maintenance, access controls are effective in limiting access to the Site.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* This alternative will not significantly limit or interfere with the ability to implement or perform future remedial actions, if any.
- *Ability to Monitor Effectiveness of Remedy:* The effectiveness of this remedy is easily monitored through visual observation of the fence during routine inspections.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve minimal disturbance of the soil. Therefore, a high ability to obtain approvals of the proposed technology (fencing) and coordinate with other agencies is anticipated.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not involve off-Site treatment, storage, and disposal.

- *Availability of Necessary Equipment and Specialists:* Site access controls (i.e., fence) are common technologies. It is anticipated that the ability to obtain the necessary materials to construct and implement them is high.
- *Availability of Prospective Technology:* Site access controls (i.e., fence) are common technologies. It is anticipated that materials needed to construct the fence are high.

6.2.7 Cost

The detailed cost estimate of this alternative is provided in Table 6-2, and the summary of the cost estimate is below:

- *Indirect Capital Cost (Design/Construction Oversight/Permits):* $56,500
- *Direct Capital Costs: $469,000*
- *Post-Construction Operation, Maintenance, and Monitoring Costs:* $144,900
- *Total Costs:* $671,000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-3.

6.3 Alternative 3 – Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goals

This alternative includes remediation of the Selected Area of the Site where COCs in surface soil contribute the majority of the risk to trespassers (adult and adolescent) in the Current and Reasonably Anticipated Future Use Scenario in the BHHRA. In addition, it includes remediation of the APCs and mostly non-vegetated areas. These areas are presented in Figure 6-2.

Site controls are described above in Remedial Alternative 2. Used in conjunction with Site controls, capping of the Selected Area would further reduce exposure to contaminated soil. Remediation for the APCs includes the following alternatives: Alternative 3a - excavation of impacted soil (to a maximum 2 ft bgs) and then consolidating the excavated soil under the cap of the Selected Area; Alternative 3b - installing a cap over each of the APCs; or Alternative 3c - excavation of impacted soil (to a maximum 2 ft bgs) and then off-Site disposal of the excavated soil. The cap components are presented in Table 6-4. Remediation of the mostly non-vegetated areas would consist of either scarifying and seeding the soil surface soil, or adding up to 1.5 feet of topsoil and seeding it. Unlike in the Selected Area and APC cap(s), the seed mix used in the non-vegetated areas could include deep-rooted plants since there is no need to prevent the roots from growing through the soil and into the underlying waste.

Capping and excavation can be performed with standard construction equipment (unless restricted by ARARs), but implementability is greatly reduced by the limited access to the Site, the need for potentially thousands of truck trips (estimated at between 19,000 and 24,000 over a two- to three-year period for this remedial alternative) to haul materials several miles through residential areas on narrow streets not built for heavy truck traffic, and large truck traffic over soft soil conditions at the Site. Cap construction and excavation will result in the destruction of the existing on-Site habitat in the capped and excavated areas, and in the areas where on-Site access roads need to be constructed. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. The relative cost of this alternative is high, due to the high cost of cap construction; the waste characterization and if necessary off-Site disposal as either hazardous or non-hazardous waste; and the cost of importing material to backfill the excavations.

6.3.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* This alternative employs Site controls including a fence and signage, and institutional controls. In addition, this alternative employs a cap system covering contaminated soil in the Selected Area and remediation (i.e., consolidation and capping, capping in place, or excavation and off-Site disposal of impacted soil) of the APCs that will reduce the potential for physical contact with contaminated soil. Remediation technologies in this alternative reduces human exposure risk by restricting access and future use, and by either creating a physical barrier from or by excavating and disposing off-Site the contaminated soil. This alternative also employs vegetative cover that will be used for the mostly non-vegetated areas shown on Figure 6-2 to reduce direct human exposure to soil at the Site. Therefore, it is anticipated that this alternative will significantly reduce the human health risk by reducing the potential for the direct exposure of human receptors using Site access controls, physical barriers, and/or removal (i.e., excavation and off-Site disposal).
- *Ecological Protection:* The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robin. Nevertheless, it is anticipated that this alternative will improve ecological protection by reducing the potential for the

direct exposure of ecological receptors using a combination of physical barriers (i.e. caps) and/or removal (i.e., excavation and off-Site disposal). However, this alternative would result in destruction of a portion of the existing habitat at the Site, requiring habitat replacement in the capped areas. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. In addition, access roads on the landfill will need to be maintained for O&M activities. Greenhouse emissions will increase due to the loss of the ecological habitat.

6.3.2 Compliance with ARARs

- *Chemical Specific ARARs:* This remedial alternative will comply with Chemical Specific ARARs relevant to the scope of this alternative. Compliance with Chemical Specific ARARs are summarized in Table 6-1.
- *Location Specific ARARs:* This remedial alternative will comply with Location Specific ARARs relevant to the scope of this alternative. Compliance with Location Specific ARARs are summarized in Table 6-1.
- *Action Specific ARARs:* This remedial alternative will comply with Action Specific ARARs relevant to the scope of this alternative. Compliance with Action Specific ARARs are summarized in Table 6-1.

6.3.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* Capping impacted soil of the Selected Area and APCs will significantly reduce the potential for direct exposure and minimize contaminant mobility (i.e., the potential for the spread of soil contamination). Excavation and off-Site disposal of impacted soil in the APCs is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for direct exposure and spread of contamination. Vegetative cover placed in non-vegetated areas will reduce direct contact with soil. Site controls will further mitigate residual risk by limiting on-Site use and access, and reducing the likelihood for direct exposure.
- *Adequacy and Reliability of Controls*: This alternative employs Site access controls that are widely used, adequate and reliable for remediation and construction. Site access controls are effective in preventing unauthorized human access on-Site. The potential for trespassing is reduced by Site controls with proper maintenance. Capping is a robust and reliable technology widely used for remediation and landfill closures to prevent direct exposure and reduce

contaminant mobility and residual risks. With proper maintenance in combination with the Site controls, the reliability of the capping system will increase. Excavation and off-Site disposal is also a widely used reliable technology for remediation of impacted soil.

6.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process used and Materials Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative does not employ remedial actions to treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative does not employ remedial actions to treat soil COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ remedial actions to treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ remedial actions to treat soil COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to treat soil COCs, and would not satisfy the statutory preference for treatment.

6.3.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* This alternative will involve controlled disturbance of the existing habitats and impacted soil during construction of the capping system, and minimal or negligible disturbance of soil during installation of Site access controls. Moderate short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, equipment, and soil transportation to and from the Site. The estimated number of truck trips to implement this remedial alternative is 19,000 to 24,000 over two to three years. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site infrequently.
- *Protection of Workers During Remedial Actions:* This alternative will involve controlled disturbance of impacted soil and construction of the fence and cap(s). The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.

- *Environmental Impacts:* This alternative will involve controlled disturbance of the existing habitat and contaminated soil during construction of the fence and cap(s). The remedial design of this alternative will take account of protection of the environment and high-value wildlife habitats (such as potential bog turtle habitats). This alternative involves disturbance of approximately 5 acres of wetlands and wetland transition areas. Mitigation (i.e., restoration, replication or relocation) of any disturbed wetlands will be implemented. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. Environmental impacts during post-construction care activities (e.g., operation, maintenance, and monitoring of the capping system) will be minimal although access roads on the landfill will need to be maintained.
- *Time Until RAOs are Achieved:* The Site access controls, capping system, and off-Site disposal will achieve the applicable RAOs upon completion of construction. It is anticipated the remedial action construction will take two to three years depending on the complexity of the final remedial design.

6.3.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative includes installing a cap system over impacted soil in the Selected Area and potentially at the APCs, constructing Site access controls (i.e., fence), and potentially soil excavation at the APCs, all of which are common technologies and straightforward to implement. There are construction challenges associated with the presence of wetlands and high-value wildlife habitats and incorporating stormwater detention basins into the limited Site space. The truck traffic along Britten Road and Green Village Road, as well as truck movement on soft, swampy soils pose additional construction challenges. This alternative does not include a treatment technology and thus post-construction operation will be limited to maintenance and monitoring of the cap system and fence. The ability to construct and operate this alternative is high.
- *Reliability of the Technology:* A cap system is a reliable physical barrier that prevents direct exposure and mitigates residual risks. Reliability of a cap system increases with appropriate maintenance and care. Access controls are widely used as a physical barrier to mitigate direct exposure. The reliability of access controls (i.e., fencing) increases with appropriate maintenance and care. With proper maintenance, access controls are effective in limiting trespassing. Excavation and

off-Site disposal is also a widely accepted reliable technology for remediation of impacted soil.

- *Ease of Undertaking Additional Remedial Actions, If Necessary:* Overall this alternative will not limit or interfere with the ability to implement or perform future remedial actions, if any. Additional remedial actions may require temporary or permanent removal of the cap system, which can be readily implemented with common construction equipment.
- *Ability to Monitor Effectiveness of Remedy:* This alternative employs physical barriers (fence and cap) that can be easily monitored through visual inspections. The effectiveness of the remedy components to reduce direct exposure risk can be assessed based on the condition of the barriers, whether they are damaged, or whether other physical factors are affecting their physical condition. The ability to monitor effectiveness of the remedy is high.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve controlled disturbance of soil and wetlands. It is anticipated that the ability to obtain approvals of the proposed technologies and to coordinate with other agencies will be high.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not involve off-Site treatment, storage, and disposal with the exception of potential disposal of impacted soil from the APCs. If an off-Site disposal technology is selected for remediation of the APCs, it is anticipated that the ability to dispose of the impacted soil at an off-Site disposal facility will be medium to high depending on the waste (i.e., excavated impacted soil) characteristics (medium for hazardous waste and high for non-hazardous waste).
- *Availability of Necessary Equipment and Specialists:* Cap systems, Site access controls (i.e., fence), and excavation/off-Site disposal are common technologies. It is anticipated that the ability to obtain the necessary equipment and personnel is high.
- *Availability of Prospective Technology:* Cap systems, Site access controls (i.e., fence), and excavation/off-Site disposal are common technologies. It is anticipated that the ability to obtain the necessary materials to construct and implement them is high.

6.3.7 Cost

The detailed cost estimate of this alternative is provided in Tables 6-5a, 6-5b, and 6-5c, and the summary of the cost estimate is below:

	Alternative 3a	Alternative 3b	Alternative 3c
Indirect Capital Costs	$ 1,881,100	$ 2,280,800	$ 2,616,700
Direct Capital Costs	$ 12,426,200	$ 15,047,300	$ 17,249,400
Post-Construction OMM Costs	$ 2,021,300	$ 2,021,300	$ 2,021,300
Total Costs(4)	$ 16,329,000	$ 19,350,000	$ 21,888,000

Notes

(1) Alternative 3a - Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation (Consolidation) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

(2) Alternative 3b - Site Controls, Capping of Selected Area to Reduce Overall Risk, and Remediation (Cap In-Place) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

(3) Alternative 3c - Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation (Off-Site Disposal) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

(4) Total costs are rounded up to the thousands place. The cost estimates assume the same technology will be applied to each APC, however it is possible that not all APCs will be remediated with the same listed technology (e.g., some may be capped, others excavated and disposed of off-Site).

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-3.

6.4 Alternative 4 – Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goals

This alternative would address the same areas as those addressed by Soil Alternative 3. Site Controls are described above. In addition to Site controls, this alternative employs excavation and off-Site disposal of impacted soil from the Selected Area to further reduce exposure to contaminated soil (Figure 6-2). Remediation for the APCs includes either (Alternative 4a) installing a cap over each of the APCs, or (Alternative 4b) excavation of impacted soil (to a maximum 2 ft bgs) and then off-Site disposal of the excavated soil. The cap components are presented in Table 6-4. Remediation of the non-vegetated areas would consist of either scarifying and seeding the soil surface soil, or adding up to 1.5 feet of topsoil and seeding it. Unlike in the Selected Area and APC cap(s), the seed mix used in the mostly non-vegetated areas could include deep-rooted plants since there is no need to prevent the roots from growing through the soil and into the underlying waste.

Capping and excavation can be performed with standard construction equipment, but implementability is greatly reduced by limited access to the Site, the need for potentially thousands of truck trips to haul materials several miles through residential areas on narrow streets not built for heavy truck traffic (estimated at 11,000 to 14,000 truck trips over two to three years), large truck traffic over soft soil conditions, and the need to characterize all the material being transported off Site (e.g., hazardous and/or non-hazardous) and identifying an appropriate disposal facility that can accept the large volume of material to be removed from the Site. Construction of the Site access roads, excavation, and capping (if included) will result in the destruction of the existing on-Site habitat. The relative cost of this alternative is high, due to the cost of waste characterization, transportation, and off-Site disposal as either hazardous or non-hazardous waste; the high cost of cap construction; and the cost of importing material to backfill the excavations.

6.4.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* This alternative employs controls on Site access using a fence and signage and institutional controls. In addition, this alternative employs off-Site disposal of contaminated soil in the Selected Area and remediation (i.e., capping in place or excavation and off-Site disposal of impacted soil) of the APCs to reduce the potential for physical contact with contaminated soil. Remediation technologies in this alternative reduce human exposure either by excavating and disposing of the contaminated soil off Site or by creating a physical barrier to direct contact. This alternative also employs vegetative cover that will be used for the mostly non-vegetated areas shown on Figure 6-2 to reduce direct human exposure to soil. Therefore, it is anticipated that this alternative, similar to Alternative 3, will significantly reduce the human health risk by reducing the potential for the direct exposure of human receptors using Site access controls, physical barriers, and/or removal (i.e., excavation and off-Site disposal).
- *Ecological Protection:* The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robin. Nevertheless, it is anticipated that this alternative, similar to Alternative 3, will improve ecological protection by reducing the potential for the direct exposure of ecological receptors using a

combination of removal of contaminated soil (i.e., excavation and off-Site disposal) and physical barriers. This alternative would result in the temporary destruction of a portion of the existing habitat and development of non-native habitat in the capped areas. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. In addition, access roads on the landfill will need to be maintained for O&M activities. Greenhouse emissions will also increase due to the loss of the ecological habitat.

6.4.2 Compliance with ARARs

- *Chemical Specific ARARs:* This remedial alternative will comply with Chemical Specific ARARs relevant to the scope of this alternative. Compliance with Chemical Specific ARARs are summarized in Table 6-1.
- *Location Specific ARARs:* This remedial alternative will comply with Location Specific ARARs relevant to the scope of this alternative. Compliance with Location Specific ARARs are summarized in Table 6-1.
- *Action Specific ARARs:* This remedial alternative will comply with Action Specific ARARs relevant to the scope of this alternative. Compliance with Action Specific ARARs are summarized in Table 6-1.

6.4.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* Excavation and off-Site disposal of impacted soil in the Selected Area and APCs is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for direct exposure and spread of contamination. Capping impacted soil of the APCs, if selected, is anticipated to significantly reduce the potential for direct exposure and minimize contaminant mobility (i.e., the potential for the spread of soil contamination). Vegetative cover placed in mostly non-vegetated areas will reduce potential exposure to COCs in soil. Site controls will further mitigate residual risk by posing limitations on Site use, access, and reducing the likelihood for direct exposure.
- *Adequacy and Reliability of Controls*: This alternative employs Site access controls that are widely used for remediation, construction, and other purposes. Site access controls are effective in preventing unauthorized human access on Site and therefore adequate and reliable. The potential for trespassing is reduced by Site controls with proper maintenance. Capping is an adequate and reliable technology widely used for remediation and landfill closures to prevent direct exposure and reduce contaminant mobility and residual risks. With proper

maintenance in combination with the Site controls, the reliability of the capping system will increase. Excavation and off-Site disposal is also a widely used adequate and reliable technology for impacted soil remediation.

6.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process used and Materials Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative does not employ remedial actions to treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative does not employ remedial actions to treat soil COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ remedial actions to treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ remedial actions to treat soil COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to treat soil COCs, and would not satisfy the statutory preference for treatment.

6.4.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* This alternative will involve controlled disturbance of existing habitat and impacted soil during excavation/construction of the capping system and minimal or negligible disturbance of soil during installation of Site access controls. High short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, equipment, and soil transportation to and from the Site. The estimated number of truck trips to implement this remedial alternative is 11,000 to 14,000 over two to three years. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site infrequently.
- *Protection of Workers During Remedial Actions:* This alternative will involve controlled disturbance of impacted soil and excavation/construction of a fence and cap, if selected. The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.

- *Environmental Impacts:* This alternative will involve controlled disturbance of ecological habitat and contaminated soil and construction of fence and cap, if selected. The remedial design of this alternative will take account of protection of the environment and high-value wildlife habitats (such as those associated with potential bog turtle habitats). This alternative involves disturbance of approximately 5 acres of wetlands and wetland transition areas. Excavated areas will be backfilled with clean material. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. Mitigation (i.e., restoration, replication or relocation) of any disturbed wetlands will be implemented. Environmental impacts during post-construction care activities (e.g., operation, maintenance, and monitoring of the capping system) will be minimal although access roads on the landfill would need to be maintained.
- *Time Until RAOs are Achieved:* The Site access controls, capping system, and off-Site disposal will achieve the applicable RAOs upon completion of construction. It is anticipated the remedial action construction will take two to three years depending on the complexity of the final remedial design and other various factors related to construction.

6.4.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative includes constructing Site access controls (i.e., fence), soil excavation, a vegetative cover in the non-vegetated areas, and potentially installing a cap system over impacted soil in APCs, all of which are common technologies and straightforward to implement. There are construction challenges associated with the presence of wetlands and high-value wildlife habitats and incorporating stormwater detention basins into the limited Site space. The truck traffic along Britten Road and Green Village Road, as well as truck movement on soft, swampy soils pose additional construction challenges. This alternative does not include a treatment technology and thus post-construction operation will be limited to maintenance and monitoring of the cap system and fence. The ability to construct and operate this alternative is moderate.
- *Reliability of the Technology:* A cap system is a reliable physical barrier that prevents direct exposure and mitigates residual risks. Reliability of a cap system increases with appropriate maintenance and care. Access controls are widely used as a physical barrier to mitigate direct exposure. The reliability of access controls (i.e., fencing) increases with appropriate maintenance and care. With proper

maintenance, access controls are effective in limiting trespassing. Excavation and off-Site disposal is also a widely accepted reliable technology for remediation of impacted soil.

- *Ease of Undertaking Additional Remedial Actions, If Necessary:* Overall this alternative will not limit or interfere with the ability to implement or perform future remedial actions, if any. Additional remedial actions may require temporary or permanent removal of the cap system, which can be readily implemented with common construction equipment.
- *Ability to Monitor Effectiveness of Remedy:* This alternative employs physical barriers (fence and cap) that can be easily monitored through visual inspections. The effectiveness of the remedy components to reduce direct exposure risk can be assessed based on the condition of the barriers, whether they are damaged, or whether other physical factors are affecting their physical condition. The ability to monitor effectiveness of the remedy is high.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve controlled disturbance of soil and wetlands. It is anticipated that the ability to obtain approvals of the proposed technologies and to coordinate with other agencies will be high.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not involve off-Site treatment and storage. It is anticipated that the ability to dispose of the impacted soil at an off-Site disposal facility will be medium to high depending on the waste (i.e., excavated impacted soil) characteristics (medium for hazardous waste and high for non-hazardous waste).
- *Availability of Necessary Equipment and Specialists:* Cap systems, Site access controls (i.e., fence), and excavation/off-Site disposal are common technologies. It is anticipated that the ability to obtain the necessary equipment and personnel is high.
- *Availability of Prospective Technology:* Cap systems, Site access controls (i.e., fence), and excavation/off-Site disposal are common technologies. It is anticipated that the ability to obtain the necessary materials to construct and implement them is high.

6.4.7 Cost

The detailed cost estimate of this alternative is provided in Tables 6-6a and 6-6b, and the summary of the cost estimate is below:

	Alternative 4a	Alternative 4b
Indirect Capital Costs	$ 2,663,300	$ 2,858,200
Direct Capital Costs	$ 29,853,800	$ 32,033,100
Post-Construction OMM Costs	$ 2,021,300	$ 484,700
Total Costs(3)	$ 34,539,000	$ 35,376,000

Notes

(1) Alternative 4a - Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation (Cap In-Place) of Areas of Particular Concern, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

(2) Alternative 4b - Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation (Off-Site Disposal) of Areas of Particular Concern, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

(3) Total costs are rounded up to the thousands place. The cost estimates assume the same technology will be applied to each APC, however it is possible that not all APCs will be remediated with the same listed technology.

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-3.

6.5 Alternative 5 – Site Controls and Capping of All Landfill Material

For this alternative, capping would include the entire landfill area of the Site, approximately 140 acres. The components of Soil Alternative 5 are illustrated on Figure 6-3. Site controls and capping are described above. The cap components are presented in Table 6-4. The APCs POI-9 and POI-14 are not located on the landfill, and therefore would be excavated (to a maximum depth of 2 ft bgs) and consolidated under the cap.

Implementability of this scenario is reduced by the need to haul a significant amount of material (i.e., significantly more material than in Soil Alternatives 3 and 4; see Tables 6-5(a,b,c) and 6-6(a,b) for the anticipated material quantities of each alternative) to the Site, requiring an estimated 98,000 truck trips over a three to four year period several miles through residential areas over narrow streets not built for heavy truck traffic. Capping will replace the existing on-Site wildlife habitat with vegetation and habitat that is not consistent with the native conditions (i.e., grasses rather than trees and shrubs). The impact of the carbon dioxide and air pollutant emissions, and habitat loss, are proportional to the size of the area capped, and therefore are much greater for Soil Alternative 5 than for Soil Alternatives 3 or 4. The relative cost of this alternative is very high, due to the high cost of importing capping materials and the need to clear the landfill portion of the Site of vegetation prior to capping.

6.5.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* This alternative employs controls on Site access using a fence with signage and institutional controls (e.g., Site Use restrictions) and capping the entire landfill area, which will reduce the potential for physical contact with contaminated soil. Remediation technologies in this alternative reduces human exposure risk by creating physical barriers from the contaminated soil. It is anticipated that this alternative will significantly reduce the human health risk by reducing the potential for the direct exposure of human receptors using Site access controls and the cap to cover all areas of the landfill.
- *Ecological Protection:* The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robin. Nevertheless, it is anticipated that this alternative will improve ecological protection by reducing the potential for the direct exposure of ecological receptors using physical barriers. While this alternative will protect against direct contact with COPECs, it would also result in destruction of the existing ecological habitat across the 140-acre landfill portion of the Site. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. Greenhouse emissions will also increase due to loss of habitat.

6.5.2 Compliance with ARARs

- *Chemical Specific ARARs:* This remedial alternative will comply with Chemical Specific ARARs relevant to the scope of this alternative. Compliance with Chemical Specific ARARs are summarized in Table 6-1.
- *Location Specific ARARs:* This remedial alternative will comply with Location Specific ARARs relevant to the scope of this alternative. Compliance with Location Specific ARARs are summarized in Table 6-1.
- *Action Specific ARARs:* This remedial alternative will comply with Action Specific ARARs relevant to the scope of this alternative. Compliance with Action Specific ARARs are summarized in Table 6-1.

6.5.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* Capping impacted soil is anticipated to significantly reduce the potential for direct exposure and minimize contaminant mobility (i.e., the potential for the spread of soil contamination). Site controls will further mitigate residual risk by posing limitations on Site access, use, and reducing the likelihood for direct exposure.
- *Adequacy and Reliability of Controls*: This alternative employs Site access controls that are widely used for remediation, construction, and other purposes. Site access controls are effective in preventing unauthorized human access on Site and are therefore adequate and reliable. The potential for trespassing is reduced by Site controls with proper maintenance. Capping is an adequate and reliable technology widely used for remediation and landfill closures to prevent direct exposure and reduce contaminant mobility and residual risks. With proper maintenance in combination with the Site controls, the reliability of the capping system will increase.

6.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process Used and Materials Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative does not employ remedial actions to treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative does not employ remedial actions to treat soil COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ remedial actions to treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ remedial actions to treat soil COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to treat soil COCs, and would not satisfy the statutory preference for treatment.

6.5.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* This alternative will involve controlled disturbance of impacted soil and destruction of ecological habitat during construction of the capping system and minimal disturbance of soil during installation of Site access controls. Minimal soil disturbances will help mitigate community and ecological impact, since no hauling of impacted materials from the Site is included in this alternative. However, significant short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, and equipment to and from the Site, including hauling cover materials for the 140-acre cap. The estimated number of truck trips to implement this remedial alternative is 98,000 over three to four years. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site infrequently.

- *Protection of Workers During Remedial Actions:* This alternative will involve controlled disturbance of impacted soil during construction of the fence and cap. The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.
- *Environmental Impacts:* This alternative will involve destruction of ecological habitat and controlled disturbance of contaminated soil during construction of the fence and cap. The remedial design of this alternative will take account of protection of the environment and high-value wildlife habitats (such as those associated with potential bog turtle habitats). This alternative involves disturbance of approximately 55 acres of wetlands and wetland transition areas, significantly more than the 5 acres disturbed under Alternatives 3 and 4. Capped areas would be revegetated with grasses that are not the naturally-occurring habitat in this area. Mitigation (i.e., restoration, replication or relocation) of disturbed wetlands will be implemented. Environmental impacts during post-construction care activities (e.g., operation, maintenance, and monitoring of the capping system) will be minimal.
- *Time Until Remedial Action Objectives are Achieved:* The Site access controls, and capping system will achieve the applicable RAOs upon completion of construction. It is anticipated the remedial action construction will take three to four years depending on the complexity of the final remedial design, time required to obtain permits, and other various factors related to construction.

6.5.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative includes constructing Site access controls (i.e., fence) and installing a cap system, which are common technologies and straightforward to implement. However, there are some construction challenges associated with the presence of wetlands and high-value wildlife habitats and incorporating stormwater detention basins into the limited Site space (construction of storm water basins may not be feasible on the capped landfill). The truck traffic along Britten Road and Green Village Road, as well as truck movement on soft, swampy soils pose additional construction challenges. This alternative does not include a treatment technology and thus post-construction operation will be limited to maintenance and monitoring of the cap system and fence. The ability to construct and operate this alternative is low to moderate.

- *Reliability of the Technology:* A cap system is a reliable physical barrier that prevents direct exposure and mitigates residual risks. Reliability of a cap system increases with appropriate maintenance and care. Access controls are widely used as a physical barrier to mitigate direct exposure. The reliability of access controls (i.e., fencing) increases with appropriate maintenance and care. With proper maintenance, access controls are effective in limiting trespassing.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* Overall this alternative will not limit or interfere with the ability to implement or perform future remedial actions, if any. Additional remedial actions may require temporary or permanent removal of the cap system, which can be readily implemented with common construction equipment.
- *Ability to Monitor Effectiveness of Remedy:* This alternative employs physical barriers (fence and cap) that can be easily monitored through visual inspections. The effectiveness of the remedy components to reduce direct exposure risk can be assessed based on the condition of the barriers, whether they are damaged, or whether other physical factors are affecting their physical condition. The ability to monitor effectiveness of the remedy is high.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve controlled disturbance of soil and wetlands, and construction in the FHA. Coordination with the USFWS will be required to cap within the GSNWR. It is anticipated that the ability to obtain approvals of the proposed technologies and to coordinate with other agencies will be moderate.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not involve off-Site treatment, storage, or disposal.
- *Availability of Necessary Equipment and Specialists:* Cap systems and Site access controls (i.e., fence) are common technologies. It is anticipated that the ability to obtain the necessary equipment and personnel is high.

- *Availability of Prospective Technology:* Cap systems and Site access controls (i.e., fence) are common technologies. It is anticipated that the ability to obtain the necessary materials to construct and implement them is high.

6.5.7 Cost

The detailed cost estimate of this alternative is provided in Table 6-7, and the summary of the cost estimate is below:

- *Indirect Capital Cost (Design/Construction Oversight/Permits):* $5,022,800
- *Direct Capital Costs:* $50,734,300
- *Post-Construction Operation, Maintenance, and Monitoring Costs:* $3,458,600
- *Total Costs:* $59,216,0000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-3.

6.6 Comparative Analysis of Alternatives

The purpose of the comparative analysis is to compare and identify the pros and cons of the soil remedial action alternatives relative to the detailed analysis criteria.

Table 6-8 presents the summary of the comparative analysis for the soil remedial action alternatives, which presents a grade for each alternative considered with respect to USEPA's criteria: 4 – Excellent, followed by 3 – Good, 2 – Moderate, and 1 – Poor. The grading scale is based on anticipated positive to negative results for each criterion. For example, if minimal to no residual risk (under the detailed analysis criterion No. 3 - Long-Term Effectiveness and Permanence) is anticipated for an alternative, it is graded as "4." The following sections present the findings of the comparative analysis.

6.6.1 Overall Protection of Human Health and the Environment

The BHHRA presumed that no remedial actions are taken to address environmental impacts that are present. The BHHRA evaluated human exposure scenarios, and results indicate that for no action (i.e., Alternative 1) (i) estimated cancer risks and non-cancer health hazard to the majority of potential receptors in the Current and Reasonably Anticipated Future Exposure Scenario (BHHRA Scenario 1) are within or less than USEPA target levels, (ii) estimated non-cancer hazard to one BHHRA Scenario 1 receptor is slightly greater than the USEPA target level, but HIs for individual target organs are all less than or equal to the USEPA target level of 1, and (iii) estimated non-cancer health hazard to two BHHRA Scenario 1 receptors (adolescent and adult trespassers) is greater than the USPEA target level. The results of the BERA indicate that, for no action, exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robin.

Because Alternatives 2 through 5 will involve remedial actions, including Site controls (i.e., physical barriers and institutional controls), capping, and/or off-Site disposal of impacted soil, additional layers of protection of human health and the environment will be provided. In comparison of Alternatives 2 through 5, Alternative 2 is anticipated to significantly reduce exposure to the COCs in soil at the Site to trespassers, but since it does not include all the remedial elements in Alternatives 3, 4, and 5, it is not as protective of human health and environment. It is anticipated that Alternative 5 will have the best overall protection of human health and the environment because the remedial actions will be implemented throughout the entire landfill. Although the areas to be remediated in Alternatives 3 and 4 are smaller than in Alternative 5, the remedial actions in Alternatives 3 and 4 are focused on the areas with the highest concentrations of COCs, so the risk reduction is nearly as good as for Alternative 5. Alternative 5 involves destroying all habitat on the landfill and replacing it with a non-native habitat (grasslands) that are not the naturally-occurring habitat in this area. The other alternatives also impact habitat but to a much lower degree than Alternative 5. Greenhouse emissions will also increase due to loss of habitat.

6.6.2 Compliance with ARARs

Alternatives 1 and 2 will not meet the Chemical Specific ARARs in the foreseeable future and therefore are the least compliant with ARARs. The remedial actions of Alternatives 3 through 5 will be designed and implemented to comply with the ARARs, and therefore compliance with ARARs of Alternatives 3 through 5 is equivalently high. However, compliance with the Wilderness Act and other ARARs applicable to the GSNWR will create additional challenges and add costs to the portions of the landfill that are on the GSNWR.

6.6.3 Long-Term Effectiveness and Permanence

Alternative 1 is no action and therefore the least effective remediation option. Alternative 2 will involve Site controls (fence and institutional controls). The long-term effectiveness and permanence of Alternative 2 is expected to be moderate. With proper management and care of Site controls and capping systems, it is anticipated that the long-term effectiveness and permanence of Alternatives 3,4, and 5 are excellent with proper care and management of Site controls and cap.

6.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The Remedial Alternatives do not include treatment and therefore do not reduce toxicity, mobility, or volume of the COCs.

6.6.5 Short-Term Effectiveness

This criterion is not applicable for Alternative 1 because no remedial action will be implemented. Alternative 5 is anticipated to be the least effective in the short term because during Alternative 5 construction the highest traffic increase and the longest construction duration are anticipated. Alternative 2 is the most effective in the short term because it causes the least traffic increase and has the shortest construction duration are anticipated.

6.6.6 Implementability

Alternative 1 will not involve any remedial action, and thus there will be no implementability issues. The implementability of Alternatives 2 through 5 is anticipated to be equivalent as the Site controls, capping, and excavation/off-Site disposal are widely used technologies for soil remediation and no implementability related issues are anticipated. Although Alternative 5 includes a similar type of construction as Alternatives 2 through 4, the size of the construction area in Alternative 5 makes implementation much more difficult.

6.6.7 Cost

Table 6-9 presents the summary of the remedial construction cost estimates for the soil Remedial Alternatives. There is no cost to implement Alternative 1 because no remedial action will be implemented. Alternative 5 is the most expensive remedial alternative as it is, by far, the biggest area to be remediated (capped) and will involve the greatest impacts on wetlands and the most extensive work in the GSNWR. While the same footprint areas will be remediated under Alternatives 3 and 4, Alternative 4 is anticipated to be more costly than Alternative 3 because off-Site disposal of impacted soil in the Selected Area is anticipated to be more expensive than capping. Alternative 2 is a relatively economical alternative.

6.6.8 Summary

Alternatives 3, 4, and 5 are evaluated to be reliable and effective alternatives that meet the threshold criteria (protection of human health and environment and compliance with ARARs) by removing or capping the impacted soil. Removal of the impacted soil is anticipated to be slightly more effective in reducing the potential for residual risk than capping, but is more costly.

For Alternatives 3, 4, and 5, the estimated timeframes to attain RAOs are similar (2 to 3 years for Alternatives 3 and 4, and 3 to 4 years for Alternative 5, depending on the complexity of a remedial design, contractor's approach and experience, permitting, and Site conditions). It is anticipated to take 6 months to one year to complete the Alternative 2 construction. While implementability of Alternatives 2 through 5 is evaluated to be similar as the Site controls, capping, and excavation/ off-Site disposal are widely used technologies and easily available, massive off-Site disposal of impacted soil (Alternative 4) may impose some challenges in finding a proper disposal facility and transportation. Alternatives 3, 4, and 5 are also anticipated to significantly increase traffic in Chatham and on Green Village and Britten Roads during remedial action implementation, with Alternative 5 having the greatest impact on traffic, and surrounding residents and businesses.

Alternative 5 will require the highest amount of remedial action construction and post-remedy operation and maintenance costs, followed by Alternatives 4, 3, and then 2.

7. DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

7.1 Alternative 1 – No Action

This alternative provides a baseline for comparing other alternatives. No remedial activities would be implemented with this alternative. Therefore, long-term human health and environmental risks for the Site will remain similar to those identified in the baseline risk assessment. There would be no additional risks posed to the community, the workers, or the environment as a result of this alternative being implemented, for example, no truck traffic to increase risks of accidents or produce carbon dioxide emissions, and no impacts to the existing habitat at the Site. There are no implementability issues or concerns and no costs associated with this remedial alternative.

7.1.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* Since the future use of the Site will not include any development, habitation, or use, groundwater will not be used and there will be no human exposure to groundwater. Since there will be no human exposure to groundwater at the Site, there is no basis to evaluate human health protection for this remedial alternative. The need to remediate groundwater results from the NJDEP GWQSs, which are ARARs.
- *Ecological Protection:* Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern. Therefore, this criterion is not applicable to the groundwater remedial alternatives.

7.1.2 Compliance with ARARs

- *Chemical Specific ARARs:* Existing concentrations of certain COCs in groundwater exceed chemical specific ARARs. This alternative does not enhance reductions in COC concentrations in groundwater (although some naturally occurring reductions have been noted), and COCs may not attenuate naturally to meet the Chemical Specific ARARs. Concentrations of metals should remain stable.
- *Location Specific ARARs:* Location specific ARARs either do not apply to this alternative or they are already met, because there are no remedial activities. This alternative does not trigger requirements for action-related permits, cause adverse impacts to natural resources and flood storage capacity, or change land use.

- *Action Specific ARARs:* Action specific ARARs do not apply for this alternative because there are no remedial activities associated with this alternative.

7.1.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* Because there are no remedial actions associated with this alternative, it is anticipated that potential future exposure to human and ecological receptors to contaminants remaining in groundwater will continue to pose the magnitude of risk as evaluated in the BHHRA and BERA although some concentration reductions have already been noted.
- *Adequacy and Reliability of Controls*: Not applicable. No controls are proposed for this alternative.

7.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process used and Materials Treated*: This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to reduce or treat groundwater COCs, and would not satisfy the statutory preference for treatment.

7.1.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* Not applicable because no remedial actions are proposed in this alternative.
- *Protection of Workers During Remedial Actions:* Not applicable because no remedial actions are proposed in this alternative.

- *Environmental Impacts:* Not applicable because no remedial actions are proposed in this alternative.
- Time Until Remedial Action Objectives *are Achieved*: No active treatment is proposed for this alternative. The time to achieve the RAOs is unknown.

7.1.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative does not employ a remedy.
- *Reliability of the Technology:* This alternative does not employ a remedy.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* This alternative does not employ a remedy.
- *Ability to Monitor Effectiveness of Remedy:* This alternative does not employ a remedy.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative does not employ a remedy.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not employ a remedy.
- *Availability of Necessary Equipment and Specialists:* This alternative does not employ a remedy.
- *Availability of Prospective Technology:* This alternative does not employ a remedy.

7.1.7 Cost

- *Indirect Capital Cost (Design/Construction Oversight/Permits):* Not applicable because no remedial action will be implemented under this alternative.
- *Direct Capital Costs:* Not applicable because no remedial action will be implemented under this alternative.
- *Post-Construction Operation, Maintenance, and Monitoring Costs:* Not applicable because no remedial action will be implemented under this alternative.
- *Total Costs:* Not applicable because no remedial action will be implemented under this alternative.

7.2 Alternative 2 – Source Control and Monitoring

This alternative relies on source control and natural processes to achieve a reduction of groundwater COCs. Source control will consist of remediating the area of test pit TP-09, where potential industrial wastes were observed. This test pit was located near and upgradient of monitoring well MW-3, which contained levels of benzene, 1,4-dioxane, and other COCs at concentrations above their GWQSs. Remediation of the test pit TP-09 area is anticipated to take place during the remedial action for soil (unless soil Remedial Alternative 1 - No Action, is selected). After this potential source area has been remediated and the selected soil remedial actions are implemented, groundwater will be monitored to observe whether COC concentrations in groundwater are stable or decreasing. If COC concentrations increase or migration away from the landfill is observed, additional remedial actions could be employed. The monitoring program will meet USEPA and NJDEP requirements, and it is anticipated that the monitoring frequency will decrease through time, as groundwater COC concentrations decline.

This alternative will include as institutional controls a Classification Exception Area (CEA) and a Well Restriction Area (WRA), which would reduce the long-term human health risks due to ingesting contaminated groundwater by prohibiting groundwater use. Periodic groundwater quality monitoring would be performed to evaluate the natural reduction in contaminants and extent of groundwater impacts.

There are little to no implementability issues or concerns with this alternative; source control is a common remediation technique for many groundwater remedies, and New Jersey has a regulatory process for establishing CEAs and WRAs. Also, the relative costs of this alternative would be low because monitoring could be performed using existing infrastructure and, if needed, additional groundwater monitoring wells.

7.2.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* Since the future use of the Site will not include any development, habitation, or use, groundwater will not be used and there will be no human exposure to groundwater. Since there will be no human exposure to groundwater, there is no basis to evaluate human health protection for this remedial alternative. The need to remediate groundwater results from the NJDEP GWQSs, which are ARARs.
- *Ecological Protection:* Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern. Therefore, this criterion is not applicable to the groundwater remedial alternatives.

7.2.2 Compliance with ARARs

- *Chemical Specific ARARs:* Existing concentrations of select compounds in groundwater exceed Chemical Specific ARARs. Concentrations of organic COCs (benzene and 1,4-dioxane) in groundwater are expected to decrease and meet the Chemical Specific ARARs. Concentrations of metals should remain stable.
- *Location Specific ARARs:* This remedial alternative will comply with relevant Location Specific ARARs. Note, source control may be achieved by either capping or removal of the material at test pit TP-09. Compliance with Location Specific ARARs are summarized in Table 7-1.
- *Action Specific ARARs:* This remedial alternative will comply with relevant Action Specific ARARs. Compliance with Action Specific ARARs are summarized in Table 7-1.

7.2.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* Source control (i.e., excavation or capping) at TP-09 is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for leaching of contaminants to groundwater. Institutional controls will further mitigate residual risk by posing limitations on Site use, access, and reducing the likelihood for direct exposure.
- Adequacy and Reliability of Controls: This alternative employs source control (i.e., excavation or capping) and institutional controls that are widely used for groundwater remediation. Institutional access controls are effective in preventing unauthorized human use of groundwater on Site and are therefore adequate and reliable. Source control is also a widely used reliable technology for remediation of groundwater.

7.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process used and Materials Treated*: This alternative relies on natural processes to reduce the groundwater COCs, and does not employ treatment to augment reductions.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative relies on natural processes to reduce groundwater COCs, and does not employ treatment to augment reductions. The magnitude of reduction in concentrations depends on natural processes and will be observed through periodic groundwater monitoring.

- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* Source control, including remediation of the area around TP-09, is anticipated to significantly reduce toxicity, mobility, or volume of groundwater COCs by removing or containing the source of the COCs.
- *Degree to which Treatment is Irreversible:* This alternative does not employ processes or treatments.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative does not employ processes or treatments to augment natural reductions. It is anticipated that residuals of some COCs, e.g., dissolved metals, will remain to some degree. The quantity depends on the potential for natural processes to effectively reduce concentrations.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative does not employ remedial actions to reduce or treat groundwater COCs.

7.2.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* The remedy includes long-term groundwater monitoring which will require small teams of personnel to access the Site infrequently. Impacts on the community will be incurred during source control activities (to be implemented concurrent with the soil remediation activities) and will be minor. The remedy also includes long-term groundwater monitoring which will require small teams of personnel to access the Site infrequently.
- *Protection of Workers During Remedial Actions:* This remedial alternative will be implemented in accordance with applicable OSHA requirements and a project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.
- *Environmental Impacts:* Source control activities will be undertaken within wetland areas and bog turtle habitat; however the required precautions will be taken to protect these areas so environmental impacts associated with the source control action are expected to be limited. Environmental impacts associated with groundwater monitoring are minimal and mostly related to installation of new monitoring wells (if any are needed) and maintaining roads and paths.
- *Time Until RAOs are Achieved*: This alternative does not employ remedial actions to reduce or treat groundwater COCs. The time to achieve the RAOs will be

evaluated through groundwater monitoring after source removal and implementation of the soil remedial actions.

7.2.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. Therefore, the ability to construct and operate the remedy is anticipated to be high.
- *Reliability of the Technology:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. Therefore, the reliability of the remedy is anticipated to be high.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* This alternative will not restrict any addition remedial actions.
- *Ability to Monitor Effectiveness of Remedy:* A monitoring plan will be developed in consultation with USEPA and NJDEP and will provide high-quality data to indicate how COC concentrations are decreasing. This will allow the effectiveness of the remedy to be evaluated, and if any changes to the remedial approach are needed they can be identified promptly.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve source control, institutional controls, and monitoring, which are widely used technologies to remediate groundwater contamination. Therefore, the ability to obtain approvals and coordinate with other agencies is anticipated to be high.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not require off-Site treatment, storage, and disposal services.
- *Availability of Necessary Equipment and Specialists:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. Therefore, the availability of necessary equipment and specialists is anticipated to be high.
- *Availability of Prospective Technology:* This alternative will involve source control and institutional controls, which are widely used technologies to remediate groundwater contamination. Therefore, the availability of the technology is anticipated to be high.

7.2.7 Cost

The detailed cost estimate of this alternative is provided in Table 7-2, and the summary of the cost estimate is below:

- *Indirect Capital Cost (Design/Construction Oversight/Permits):* $16,300
- *Direct Capital Costs:* $86,500
- *Post-Construction Operation, Maintenance, and Monitoring Costs:* $1,195,000
- *Total Costs:* $1,298,000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 7-3.

7.3 Alternative 3 – Biological Treatment and Monitoring

This alternative will employ biological treatment along with monitoring and institutional controls. Monitoring with institutional controls is described above in Groundwater Alternative 2. Where source materials continue to contribute COCs to groundwater, a biological treatment (i.e., either enhanced reductive chlorination, aerobic bioremediation, or phytoremediation) will be implemented. This alternative also includes institutional controls (CEA and WRA).

Biological treatment is effective for the majority of the Site COCs with some limitations for the treatment of PCBs and metals (these COCs are found beneath the landfill and do not appear likely to migrate away from the landfill). The biological treatment methods considered herein include: enhanced reductive dechlorination, aerobic bioremediation, and phytoremediation. Implementability should be high. The relative cost of biological treatment will depend on the selected technology and ranges from medium to high.

7.3.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* Since the future use of the Site will not include any development, habitation, or use, groundwater will not be used and there will be no human exposure to groundwater. Since there will be no human exposure to groundwater at the Site, there is no basis to evaluate human health protection for this remedial alternative. The need to remediate groundwater results from the NJDEP GWQSs, which are ARARs.
- *Ecological Protection:* Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern. Therefore, this criterion is not applicable to the groundwater remedial alternatives.

7.3.2 Compliance with ARARs

- *Chemical Specific ARARs:* This remedial alternative will comply with relevant Chemical Specific ARARs. It is anticipated that the majority of groundwater COCs will be treated through a selected biological treatment and some PCBs and metal COCs in groundwater by natural processes. Compliance with Chemical Specific ARARs are summarized in Table 7-1.
- *Location Specific ARARs:* This remedial alternative will comply with relevant Location Specific ARARs. Compliance with Location Specific ARARs are summarized in Table 7-1.
- *Action Specific ARARs:* This remedial alternative will comply with relevant Action Specific ARARs. Compliance with Action Specific ARARs are summarized in Table 7-1.

7.3.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* This alternative employs a combination of biological treatment, natural processes, and institutional controls which will significantly reduce COC concentrations. There is low residual risk for this alternative.
- *Adequacy and Reliability of Controls*: Enhanced reductive dechlorination, aerobic bioremediation, phytoremediation, natural processes, and institutional controls are widely used and are adequate and reliable technologies to reduce the concentrations of COCs in groundwater at the Site. In addition, performance of the remedy will be evaluated through long-term groundwater monitoring. Reliability and effectiveness of the controls are anticipated to be moderate to high.

7.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process used and Materials Treated*: Biological treatment will be applied to groundwater to reduce COC concentrations. Treatment may include enhanced reductive dechlorination, aerobic bioremediation, or phytoremediation.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative employs biological treatment to groundwater to reduce COC concentrations. The quantity of groundwater treated will be based on the specific treatment selected; however, the goal will be to treat the organic COCs in groundwater impacted within the shallow water-bearing zone around MW-3.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative employs biological treatment to groundwater which

is expected to reduce the toxicity or volume of contaminants in the groundwater. The degree of expected reductions in toxicity, mobility and volume through this treatment alternative is high.

- *Degree to which Treatment is Irreversible:* This alternative employs a biological treatment to the groundwater to reduce concentrations of groundwater COCs. Biological treatments will create nearly to complete irreversible changes to benzene and 1,4-dioxane, with some limitations for PCB and metal COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative employs a biological treatment to the groundwater to reduce concentrations of groundwater COCs. The biological treatment is anticipated to be effective in reducing concentrations of benzene and 1,4-dioxane in the groundwater and the residual concentration is anticipated to be below PRGs. The anticipated quantity of residual PCBs and metals after treatment is expected to be the same or less than the current concentrations.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative employs biological treatment and would satisfy the statutory preference for remedial actions to include treatment technologies.

7.3.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* This alternative will involve controlled and limited disturbance of soil (and potentially landfilled waste) during construction and implementation of the biological treatment system, and may require pilot testing. Moderate short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, and equipment transportation to and from the Site. The remedy also includes long-term groundwater monitoring which will require small teams of personnel to access the Site infrequently.
- *Protection of Workers During Remedial Actions:* This alternative will involve controlled and limited disturbance of soil (and potentially landfilled waste) and construction of a treatment system. The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.
- *Environmental Impacts:* This alternative will involve limited disturbance of soil (and potentially landfilled waste). Construction may impact wetlands; however,

it is anticipated that the area of disturbed wetlands due to this alternative will be insignificant and thus mitigation of disturbed wetlands can be implemented on-Site depending on the selected soil remedy alternative. Per the BERA, there may be high-value wildlife habitats (such as potential bog turtle habitats) in several areas of the Site. The remedial design will take account of protection of the habitats. Except for the maintenance of roads and paths, it is anticipated that post-construction care activities (e.g., operation, maintenance, and monitoring) will have minimal to no environmental impacts.

- *Time Until RAOs are Achieved:* It is anticipated the RA construction will vary greatly depending on the selected technologies for biological treatment. Refined estimates of the time required to achieve RAOs will be provided as part of the remedial design.

7.3.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative includes biological treatment, which is a common technology and relatively straightforward to implement. There are design challenges associated with the presence of wetlands and high-value wildlife habitats, and with the need to work in the subsurface of the landfill, which can be highly heterogeneous. The ability to construct and operate is moderate.
- *Reliability of the Technology:* Enhanced reductive dechlorination, aerobic bioremediation, and phytoremediation are widely-used and reliable technologies to control contaminated groundwater. However, the reliability of this technology in groundwater within or directly below the landfill is likely reduced because of potential interferences from the waste materials. The reliability of the specific technologies employed for this alternative will be considered during design.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* Additional remedial actions may require the temporary or permanent disruption or removal of the biological treatment system. However, it is anticipated that additional remedial actions may be undertaken without significant technical difficulties.
- *Ability to Monitor Effectiveness of Remedy:* This alternative includes long-term monitoring of the groundwater downgradient of MW-3. The effectiveness of this remedy will be monitored through groundwater sampling and testing.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve controlled disturbance of the soil, landfilled waste, and/or

wetlands. It is anticipated that the ability to obtain approvals of the proposed technologies and to coordinate with other agencies will be moderate.

- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative employs technologies that will likely not require off-Site treatment, storage or disposal of groundwater or source materials.
- *Availability of Necessary Equipment and Specialists:* Enhanced reductive dechlorination, aerobic bioremediation, and phytoremediation are common technologies. It is anticipated that the ability to obtain the necessary equipment and personnel is high.
- *Availability of Prospective Technology:* Enhanced reductive dechlorination, aerobic bioremediation, and phytoremediation are common techniques. It is anticipated that the ability to obtain the necessary materials to construct and implement them is high.

7.3.7 Cost

The detailed cost estimate of this alternative is provided in Tables 7-4a and 7-4b, and the summary of the cost estimate is below:

	Alternative 3a	Alternative 3b
Indirect Capital Costs	$97,400	$101,900
Direct Capital Costs	$521,100	$544,900
Post-Construction OMM Costs	$1,195,000	$1,645,000
Total Costs(3)	$1,814,000	$2,292,000

Notes
(1) Alternative 3a – Biological Treatment and Monitoring via Enhanced Biodegradation
(2) Alternative 3b – Biological Treatment and Monitoring via Phytoremediation
(3) Total costs are rounded up to the thousands place

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 7-3.

7.4 Alternative 4 – Chemical Treatment and Monitoring

This alternative will employ chemical treatment along with monitoring and institutional controls. Monitoring with institutional controls is described in Groundwater Alternative 2. Where source materials continue to contribute COCs to groundwater, a chemical treatment (i.e., either in-situ chemical reduction or oxidation) will be implemented. This alternative also includes institutional controls (CEA and WRA).

Chemical treatments are effective for the Site COCs. Implementability is moderate with standard equipment and materials. The relative cost of this alternative is high.

7.4.1 Overall Protection of Human Health and the Environment

- *Human Health Protection:* Since the future use of the Site will not include any development, habitation, or use, groundwater will not be used and there will be no human exposure to groundwater. Since there will be no human exposure to groundwater at the Site, there is no basis to evaluate human health protection for this remedial alternative. The need to remediate groundwater results from the NJDEP GWQSs, which are ARARs.
- *Ecological Protection:* Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern. Therefore, this criterion is not applicable to the groundwater remedial alternatives.

7.4.2 Compliance with ARARs

- *Chemical Specific ARARs:* This remedial alternative will comply with Chemical Specific ARARs relevant to the scope of this alternative. Compliance with Chemical Specific ARARs are summarized in Table 7-1.
- *Location Specific ARARs:* This remedial alternative will comply with Location Specific ARARs relevant to the scope of this alternative. Compliance with Location Specific ARARs are summarized in Table 7-1.
- *Action Specific ARARs:* This remedial alternative will comply with Action Specific ARARs relevant to the scope of this alternative. Compliance with Action Specific ARARs are summarized in Table 7-1.

7.4.3 Long-Term Effectiveness and Permanence

- *Magnitude of Residual Risk:* This alternative employs a combination of chemical treatment of contaminated groundwater, natural processes, and institutional controls which can reduce COC concentrations in groundwater. There is moderate residual risk for this alternative.

- *Adequacy and Reliability of Controls:* In-situ chemical treatment and institutional controls are widely used and are adequate technologies to effectively reduce COC concentrations in groundwater at the Site. However, Site-specific factors, such as the presence of organic material in the landfill waste, may hinder the effectiveness of chemical reactants, potentially rendering this approach ineffective. Performance of the remedy will be evaluated through long-term groundwater monitoring.

7.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

- *Treatment Process used and Materials Treated*: Chemical treatment will be applied to groundwater to reduce COC concentrations. Treatment may include in-situ oxidation or reduction.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative employs chemical treatment to groundwater to reduce COC concentrations. The quantity of groundwater treated will be based on the specific treatment selected; however, the goal will be to treat the groundwater impacted within the shallow water-bearing zone around MW-3.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative employs chemical treatment to groundwater which is expected to reduce the toxicity or volume of contaminants in the groundwater. The degree of expected reductions in toxicity, mobility and volume through this treatment alternative is moderate to high.
- *Degree to which Treatment is Irreversible:* This alternative employs a chemical treatment (in-situ oxidation or reduction) to the groundwater to reduce concentrations of groundwater COCs. Chemical treatments will create irreversible changes to the COCs.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative employs a chemical treatment to the groundwater to reduce concentrations of groundwater COCs. The chemical treatment is anticipated to be effective in reducing concentrations in the groundwater and the residual concentration is anticipated to be below target levels. The anticipated quantity of residuals after treatment is marginal.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative employs chemical treatment and would

satisfy the statutory preference for remedial actions to include treatment technologies.

7.4.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* This alternative will involve controlled and limited disturbance of soil (and potentially landfilled waste) during construction and implementation of the chemical treatment system. Moderate short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, and equipment transportation to and from the Site. The remedy also includes long-term groundwater monitoring which will require small teams of personnel to access the Site infrequently.
- *Protection of Workers During Remedial Actions:* This alternative will involve controlled and limited disturbance of the soil (and potentially landfilled waste). The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk.
- *Environmental Impacts:* This alternative will involve limited disturbance of soil (and potentially landfilled waste). Construction may impact wetlands; however, it is anticipated that the disturbed wetlands area due to this alternative will be insignificant and thus mitigation of disturbed wetlands can be implemented on Site. Per the BERA, there may be high-value wildlife habitats (such as potential bog turtle habitats) in several areas of the Site. The remedial design will take account of protection of the habitats. Except for the maintenance of roads and paths, it is anticipated that post-construction care activities (e.g., operation, maintenance, and monitoring) will have minimal to no environmental impacts.
- *Time Until RAOs are Achieved:* It is anticipated the time for remedial action construction will vary greatly depending on the selected technologies for chemical treatment. Refined estimates of the time required to achieve RAOs will be provided as part of the remedial design.

7.4.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative includes chemical treatment, which is a common technology and relatively straightforward to implement. There are design challenges associated with the presence of wetlands and high-value wildlife habitats, and with the need to work in the subsurface of the landfill, which can be highly heterogeneous. In addition, the presence of organic materials in the landfilled wastes can interfere with chemical oxidation of the COCs, potentially rendering this approach ineffective. The ability to construct and operate is moderate.

- *Reliability of the Technology:* In-situ oxidation and reduction are widely-used and reliable technologies to control contaminated groundwater. However, the reliability of this technology in groundwater within or directly below the landfill is likely reduced because of potential interferences from the waste materials. The reliability of the specific technologies employed for this alternative will be considered during design.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* Additional remedial actions may require the temporary or permanent disruption or removal of the chemical treatment system. However, it is anticipated that additional remedial actions may be undertaken without significant technical difficulties.
- *Ability to Monitor Effectiveness of Remedy:* This alternative includes long-term monitoring of the groundwater downgradient of MW-3. The effectiveness of this remedy will be monitored through groundwater sampling and testing.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve controlled disturbance of the soil, landfilled waste, and/or wetlands. It is anticipated that the ability to obtain approvals of the proposed technologies and to coordinate with other agencies will be moderate.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative employs technologies that will likely not require off-Site treatment, storage or disposal of groundwater or source materials.
- *Availability of Necessary Equipment and Specialists:* In-situ oxidation and reduction are common technologies. It is anticipated that the ability to obtain the necessary equipment and personnel is high.
- *Availability of Prospective Technology:* In-situ oxidation and reduction are common techniques. It is anticipated that the ability to obtain the necessary materials to construct and implement them is high.

7.4.7 Cost

The detailed cost estimate of this alternative is provided in Tables 7-5a and 7-5b, and the summary of the cost estimate is below:

	Alternative 4a	Alternative 4b
Indirect Capital Costs	$279,300	$461,100
Direct Capital Costs	$1,496,100	$2,471,100
Post-Construction OMM Costs	$1,195,000	$1,195,000
Total Costs(3)	$2,971,000	$4,128,000

Notes
(1) Alternative 4a – Chemical Treatment and Monitoring via In-Situ Chemical Oxidation
(2) Alternative 4b – Chemical Treatment and Monitoring via In-Situ Chemical Reduction
(3) Total costs are rounded up to the thousands place

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 7-3.

7.5 Comparative Analysis of Alternatives

Th comparative analysis is to compare and identify the pros and cons of the groundwater remedial action alternatives relative to the detailed analysis criteria.

Table 7-6 presents the summary of the comparative analysis for the groundwater remedial action alternatives, which presents a grade for each alternative considered with respect to each of USEPA's nine criteria: 4 – Excellent, followed by 3 – Good, 2 – Moderate, and 1 – Poor. The grading scale is based on anticipated positive to negative results for each criterion. For example, if minimal to no residual risk (under the detailed analysis criterion No. 3 Long-Term Effectiveness and Permanence) is anticipated for an alternative, it is graded as "4." The following sections present the findings of the comparative analysis.

7.5.1 Overall Protection of Human Health and the Environment

There will be no future use of the Site so groundwater at the Site will not be used in any way. Groundwater impacts are limited to the landfill itself or adjacent areas. There are no human groundwater receptors in the vicinity of the Site, and no risks have been identified in surface water that groundwater from the Site might flow to. Groundwater sampling results indicate that concentrations of COCs are stable or decreasing. Remedial Alternatives 2, 3, and 4 include institutional controls (CEA and WRA) consistent with NJDEP requirements, which will serve as notice to the public of the groundwater conditions at the Site. No other actions are required to protect human health or the environment.

7.5.2 Compliance with ARARs

Alternatives 1 will not meet the Chemical Specific ARARs and therefore is the least compliant with ARARs. Alternatives 2, 3, and 4 all include measures (monitoring, natural processes and either source control or groundwater treatment) to reduce the concentrations of COCs in groundwater with the goal of compliance with ARARs (New Jersey GWQSs).

7.5.3 Long-Term Effectiveness and Permanence

Alternative 1 is no action and therefore the least effective remediation option. Alternative 2 will involve institutional controls, source control, natural processes, and monitoring. The long-term effectiveness and permanence of Alternative 2 is anticipated to be moderate to high. With proper O&M of biological or chemical treatment systems, it is anticipated that the long-term effectiveness and permanence of Alternatives 3 and 4 is usually high. However, the effectiveness of biological or chemical treatment could be reduced by the heterogeneity of the landfilled material and the likely presence of large amounts of organic material or other materials that could interfere with the treatment processes.

7.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 1 and 2 do not include treatment. Alternative 3 is expected to have slightly less ability to reduce toxicity and mobility of the groundwater COCs than Alternative 4 because Alternative 3 will utilize biological treatment, which may have some treatability limitations to some PCB and metals in groundwater.

7.5.5 Short-Term Effectiveness

Alternative 1 involves no construction. Alternative 2 includes source control, which is expected to have an immediate beneficial effect by removing a source of COCs to groundwater. However, that effect may require several years to be evident in groundwater monitoring wells located downgradient of the area where source removal is implemented. Alternatives 3 and 4 include direct treatment of COCs in groundwater and their short-term effectiveness is expected to be better than for Alternative 2.

7.5.6 Implementability

This criterion is not applicable for Alternative 1 because no remedial action will be implemented. The implementability of Alternative 2 is anticipated to be highest, since source removal can be conducted using typical construction techniques. Implementability of Alternatives 3 and 4 is anticipated to be moderate to high as the biological and chemical treatment are widely used technologies for groundwater remediation. However, this could be offset by Site conditions that make implementation physically difficult (heterogeneity in the landfill that could interfere with injections) and reduce the effectiveness of the biological and chemical processes these remedies rely on.

7.5.7 Cost

Table 7-7 presents the summary of the remedial construction cost estimates for the soil Remedial Alternatives. This criterion is not applicable for Alternative 1 because no remedial action will be implemented. Alternative 4 is the most expensive remedial alternative, followed by Alternative 3 and then Alternative 2.

7.5.8 Summary

Alternative 1 involves no action, and therefore does not actively improve groundwater conditions relative to ARARs, although some further reduction in groundwater COC concentrations is expected to occur naturally (based on observations of declining concentration trends for certain of the Site COCs).

Alternative 2 includes source control, which is an essential component of most groundwater remedies, and is expected to have an immediate beneficial impact on groundwater conditions. This benefit may not be observed in groundwater samples until a year or more after source removal is conducted. This alternative also includes natural processes to reduce COC concentrations. The remedial components of Alternative 2 are straight-forward and readily implementable. Long-term monitoring will provide data to evaluate the success of the source control, and allow adjustments to be made to the remedy in the future, if any adjustments are needed.

Alternatives 3 and 4 are evaluated to be reliable and effective alternatives that meet the threshold criteria (protection of human health and environment and compliance with ARARs) by treating the impacted groundwater. Alternative 3 is anticipated to take more time to attain the RAOs than Alternative 4 as in general a biological treatment process requires more time than a chemical treatment process. Both are expected to reduce groundwater COC concentrations in the short-term more effectively that Alternative 2.

However, their implementability is lower than Alternative 2 due to Site conditions, and their long-term effectiveness (time to reach ARARs at the Site overall) is likely no greater than Alternative 2. Like Alternative 2, Alternatives 3 and 4 include long-term monitoring so the effectiveness of the remedy can be assessed and adjustments can be made, if needed.

8. SUMMARY AND CONCLUSIONS

This FS Report is based on a thorough study of environmental conditions at the Rolling Knolls Superfund Site, implemented in conjunction with USEPA and NJDEP. The RI of the Site included multi-phased investigations of all environmental media, including soil, groundwater, surface water, sediment, and indoor air. In addition, human health and ecological risks have been quantified. Based on the results of this work, remediation of soil and groundwater at the Site is needed to reduce risks to human health and the environment, and to meet ARARs.

The data available are more than adequate to identify and compare remedial alternatives. This has been completed through a multi-phase process including the TMCT, DSRA, and this FS Report. The evaluation is based on the expectation that the landfill portion of the Site will not be used in the future for any residential, commercial, industrial, recreational or other purposes. Therefore, the only potential human receptors on the landfill portion of the Site are trespassers and there will be no groundwater use at the Site.

Based on the results of prior screening of remedial options, the following five Remedial Alternatives for soil were evaluated in this FS:

1) No Action;
2) Site Controls (i.e., Institutional Controls and Access Restrictions);
3) Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals;
4) Site Controls, Excavation and Off-Site Disposal of Select Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals; and,
5) Site Controls and Capping of All Landfill Material.

The following table summarizes the characteristics of each Soil Remedial Alternative when compared to USEPA's evaluation criteria.

Evaluation Criteria	Soil Alternatives				
	1	2	3	4	5
Overall Protection of Human Health and the Environment	Poor	Good	Excellent	Excellent	Excellent
Compliance with ARARs	Poor	Good	Excellent	Excellent	Excellent
Long-Term Effectiveness and Permanence	Poor	Moderate	Excellent	Excellent	Excellent
Reduction of Toxicity, Mobility, and Volume Through Treatment	None	None	None	None	None
Short-Term Effectiveness	NA	Excellent	Good	Moderate	Poor
Implementability	NA	Excellent	Excellent	Excellent	Excellent
Costs	$0	$671,000	$16,329,000 to $21,888,000	$34,539,000 to $35,376,000	$59,216,000

NA - Not Applicable
For Soil Alternatives 3 and 4, the range of costs reflects differing remedial approaches included within the alternative.

The No Action alternative provides the least overall protection but entails no impact to the surrounding community and has no cost. Soil Alternative 2, Site Controls, provides good overall protection and compliance with ARARs, has minimal impact on the community, and at a low cost. Alternatives 3 and 4 comprise remediation of the Selected Area of the Site to reduce the overall risk to potential trespassers identified during the human health risk assessment, and remediation of other specific areas of the Site to further reduce risks. They provide excellent overall protection, comply with ARARs, and provide excellent long-term protection. However, Alternative 3 has better short-term effectiveness because it has fewer impacts to the community, and is more cost effective than Alternative 4. Alternative 5 is similar to Alternatives 3 and 4 in terms of overall protection, compliance with ARARs, and long-term effectiveness. However, this alternative will have the greatest impact on the community, and destroys the existing habitat at the Site, replacing it with a new habitat (grasslands) that did not occur naturally at the Site. Alternative 5 is also substantially more expensive than any other alternative.

Based on the results of prior screening of remedial options, the following four Remedial Alternatives for groundwater were evaluated in this FS:

1) No Action;
2) Source Control and Monitoring;
3) Biological Treatment and Monitoring; and,
4) Chemical Treatment and Monitoring.

The following table summarizes the characteristics of each Groundwater Remedial Alternative when compared to USEPA's evaluation criteria.

Evaluation Criteria	Groundwater Alternatives			
	1	2	3	4
Overall Protection of Human Health and the Environment	Poor	Good	Good	Good
Compliance with ARARs	Poor	Excellent	Excellent	Excellent
Long-Term Effectiveness and Permanence	Poor	Moderate	Good	Good
Reduction of Toxicity, Mobility, and Volume Through Treatment	Poor	Moderate	Good	Good
Short-Term Effectiveness	NA	Excellent	Excellent	Good
Implementability	NA	Excellent	Good	Moderate - Good
Costs	$0	$1,298,000	$1,814,000 to $2,292,000	$2,971,000 to $4,128,000

NA - Not Applicable
For Groundwater Alternatives 3 and 4, the range of costs reflects differing remedial approaches included within the alternative.

Alternative 1, No Action, provides the least protection but has no implementability concerns and has no cost. Alternative 2 comprises source control and groundwater monitoring; it provides good overall protection and excellent compliance with ARARs, low community impacts, excellent implementability, and is cost effective. Alternatives 3 and 4 are similar in that they include biological treatment (Alternative 3) or chemical treatment (Alternative 4) followed by groundwater monitoring. Similar to Alternative 2, they provide good overall protection and excellent compliance with ARARs. However, Alternatives 3 and 4 will be subject to implementation concerns due to the nature of the landfilled materials, and have a much higher cost than Alternative 2.

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TABLES

FIGURES